

JURASSIC

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## 1 Main Page

The Juelich RAPid Spectral Simulation Code (JURASSIC) is a fast radiative transfer model for the mid-infrared spectral region. This reference manual provides information on the algorithms and data structures used in the code. Further information can be found at: <http://www.fz-juelich.de/ias/jsc/jurassic>

## 2 Data Structure Index

### 2.1 Data Structures

Here are the data structures with brief descriptions:

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## 3 File Index

### 3.1 File List

Here is a list of all files with brief descriptions:

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## 4 Data Structure Documentation

### 4.1 atm\_t Struct Reference

Atmospheric data.

```
#include <jurassic.h>
```

#### Data Fields

- int [np](#)  
*Number of data points.*
- double [time](#) [NP]  
*Time (seconds since 2000-01-01T00:00Z).*
- double [z](#) [NP]  
*Altitude [km].*
- double [lon](#) [NP]  
*Longitude [deg].*
- double [lat](#) [NP]  
*Latitude [deg].*
- double [p](#) [NP]

- Pressure [hPa].*
- double [t](#) [NP]
- Temperature [K].*
- double [q](#) [NG][NP]
- Volume mixing ratio.*
- double [k](#) [NW][NP]
- Extinction [1/km].*

#### 4.1.1 Detailed Description

Atmospheric data.

Definition at line [219](#) of file [jurassic.h](#).

#### 4.1.2 Field Documentation

##### 4.1.2.1 int atm\_t::np

Number of data points.

Definition at line [222](#) of file [jurassic.h](#).

##### 4.1.2.2 double atm\_t::time[NP]

Time (seconds since 2000-01-01T00:00Z).

Definition at line [225](#) of file [jurassic.h](#).

##### 4.1.2.3 double atm\_t::z[NP]

Altitude [km].

Definition at line [228](#) of file [jurassic.h](#).

##### 4.1.2.4 double atm\_t::lon[NP]

Longitude [deg].

Definition at line [231](#) of file [jurassic.h](#).

##### 4.1.2.5 double atm\_t::lat[NP]

Latitude [deg].

Definition at line [234](#) of file [jurassic.h](#).

##### 4.1.2.6 double atm\_t::p[NP]

Pressure [hPa].

Definition at line [237](#) of file [jurassic.h](#).

4.1.2.7 `double atm_t::t[NP]`

Temperature [K].

Definition at line 240 of file [jurassic.h](#).

4.1.2.8 `double atm_t::q[NG][NP]`

Volume mixing ratio.

Definition at line 243 of file [jurassic.h](#).

4.1.2.9 `double atm_t::k[NW][NP]`

Extinction [1/km].

Definition at line 246 of file [jurassic.h](#).

The documentation for this struct was generated from the following file:

- [jurassic.h](#)

4.2 `ctl_t` Struct Reference

Forward model control parameters.

```
#include <jurassic.h>
```

## Data Fields

- `int ng`  
*Number of emitters.*
- `char emitter [NG][LEN]`  
*Name of each emitter.*
- `int nd`  
*Number of radiance channels.*
- `int nw`  
*Number of spectral windows.*
- `double nu [ND]`  
*Centroid wavenumber of each channel [cm<sup>-1</sup>].*
- `int window [ND]`  
*Window index of each channel.*
- `char tblbase [LEN]`  
*Basename for table files and filter function files.*
- `double hydZ`  
*Reference height for hydrostatic pressure profile (-999 to skip) [km].*
- `int ctm_co2`  
*Compute CO2 continuum (0=no, 1=yes).*
- `int ctm_h2o`  
*Compute H2O continuum (0=no, 1=yes).*



- int [ctm\\_n2](#)  
*Compute N2 continuum (0=no, 1=yes).*
- int [ctm\\_o2](#)  
*Compute O2 continuum (0=no, 1=yes).*
- int [refrac](#)  
*Take into account refractivity (0=no, 1=yes).*
- double [rayds](#)  
*Maximum step length for raytracing [km].*
- double [raydz](#)  
*Vertical step length for raytracing [km].*
- char [fov](#) [LEN]  
*Field-of-view data file.*
- double [retp\\_zmin](#)  
*Minimum altitude for pressure retrieval [km].*
- double [retp\\_zmax](#)  
*Maximum altitude for pressure retrieval [km].*
- double [rett\\_zmin](#)  
*Minimum altitude for temperature retrieval [km].*
- double [rett\\_zmax](#)  
*Maximum altitude for temperature retrieval [km].*
- double [retq\\_zmin](#) [NG]  
*Minimum altitude for volume mixing ratio retrieval [km].*
- double [retq\\_zmax](#) [NG]  
*Maximum altitude for volume mixing ratio retrieval [km].*
- double [retk\\_zmin](#) [NW]  
*Minimum altitude for extinction retrieval [km].*
- double [retk\\_zmax](#) [NW]  
*Maximum altitude for extinction retrieval [km].*
- int [write\\_bbt](#)  
*Use brightness temperature instead of radiance (0=no, 1=yes).*
- int [write\\_matrix](#)  
*Write matrix file (0=no, 1=yes).*

#### 4.2.1 Detailed Description

Forward model control parameters.

Definition at line [251](#) of file [jurassic.h](#).

#### 4.2.2 Field Documentation

##### 4.2.2.1 int [ctl\\_t::ng](#)

Number of emitters.

Definition at line [254](#) of file [jurassic.h](#).

#### 4.2.2.2 `char ctl_t::emitter[NG][LEN]`

Name of each emitter.

Definition at line 257 of file [jurassic.h](#).

#### 4.2.2.3 `int ctl_t::nd`

Number of radiance channels.

Definition at line 260 of file [jurassic.h](#).

#### 4.2.2.4 `int ctl_t::nw`

Number of spectral windows.

Definition at line 263 of file [jurassic.h](#).

#### 4.2.2.5 `double ctl_t::nu[ND]`

Centroid wavenumber of each channel [ $\text{cm}^{-1}$ ].

Definition at line 266 of file [jurassic.h](#).

#### 4.2.2.6 `int ctl_t::window[ND]`

Window index of each channel.

Definition at line 269 of file [jurassic.h](#).

#### 4.2.2.7 `char ctl_t::tblbase[LEN]`

Basename for table files and filter function files.

Definition at line 272 of file [jurassic.h](#).

#### 4.2.2.8 `double ctl_t::hydz`

Reference height for hydrostatic pressure profile (-999 to skip) [km].

Definition at line 275 of file [jurassic.h](#).

#### 4.2.2.9 `int ctl_t::ctm_co2`

Compute CO2 continuum (0=no, 1=yes).

Definition at line 278 of file [jurassic.h](#).

#### 4.2.2.10 `int ctl_t::ctm_h2o`

Compute H2O continuum (0=no, 1=yes).

Definition at line 281 of file [jurassic.h](#).

#### 4.2.2.11 `int ctl_t::ctm_n2`

Compute N2 continuum (0=no, 1=yes).

Definition at line 284 of file [jurassic.h](#).

#### 4.2.2.12 `int ctl_t::ctm_o2`

Compute O2 continuum (0=no, 1=yes).

Definition at line 287 of file [jurassic.h](#).

#### 4.2.2.13 `int ctl_t::refrac`

Take into account refractivity (0=no, 1=yes).

Definition at line 290 of file [jurassic.h](#).

#### 4.2.2.14 `double ctl_t::rayds`

Maximum step length for raytracing [km].

Definition at line 293 of file [jurassic.h](#).

#### 4.2.2.15 `double ctl_t::raydz`

Vertical step length for raytracing [km].

Definition at line 296 of file [jurassic.h](#).

#### 4.2.2.16 `char ctl_t::fov[LEN]`

Field-of-view data file.

Definition at line 299 of file [jurassic.h](#).

#### 4.2.2.17 `double ctl_t::retp_zmin`

Minimum altitude for pressure retrieval [km].

Definition at line 302 of file [jurassic.h](#).

#### 4.2.2.18 `double ctl_t::retp_zmax`

Maximum altitude for pressure retrieval [km].

Definition at line 305 of file [jurassic.h](#).

#### 4.2.2.19 `double ctl_t::rett_zmin`

Minimum altitude for temperature retrieval [km].

Definition at line 308 of file [jurassic.h](#).

**4.2.2.20 double ctl\_t::rett\_zmax**

Maximum altitude for temperature retrieval [km].

Definition at line 311 of file [jurassic.h](#).

**4.2.2.21 double ctl\_t::retq\_zmin[NG]**

Minimum altitude for volume mixing ratio retrieval [km].

Definition at line 314 of file [jurassic.h](#).

**4.2.2.22 double ctl\_t::retq\_zmax[NG]**

Maximum altitude for volume mixing ratio retrieval [km].

Definition at line 317 of file [jurassic.h](#).

**4.2.2.23 double ctl\_t::retk\_zmin[NW]**

Minimum altitude for extinction retrieval [km].

Definition at line 320 of file [jurassic.h](#).

**4.2.2.24 double ctl\_t::retk\_zmax[NW]**

Maximum altitude for extinction retrieval [km].

Definition at line 323 of file [jurassic.h](#).

**4.2.2.25 int ctl\_t::write\_bbt**

Use brightness temperature instead of radiance (0=no, 1=yes).

Definition at line 326 of file [jurassic.h](#).

**4.2.2.26 int ctl\_t::write\_matrix**

Write matrix file (0=no, 1=yes).

Definition at line 329 of file [jurassic.h](#).

The documentation for this struct was generated from the following file:

- [jurassic.h](#)

**4.3 los\_t Struct Reference**

Line-of-sight data.

```
#include <jurassic.h>
```

## Data Fields

- int **np**  
*Number of LOS points.*
- double **z** [NLOS]  
*Altitude [km].*
- double **lon** [NLOS]  
*Longitude [deg].*
- double **lat** [NLOS]  
*Latitude [deg].*
- double **p** [NLOS]  
*Pressure [hPa].*
- double **t** [NLOS]  
*Temperature [K].*
- double **q** [NG][NLOS]  
*Volume mixing ratio.*
- double **k** [NW][NLOS]  
*Extinction [1/km].*
- double **tsurf**  
*Surface temperature [K].*
- double **ds** [NLOS]  
*Segment length [km].*
- double **u** [NG][NLOS]  
*Column density [molecules/cm<sup>2</sup>].*

### 4.3.1 Detailed Description

Line-of-sight data.

Definition at line 334 of file [jurassic.h](#).

### 4.3.2 Field Documentation

#### 4.3.2.1 int los\_t::np

Number of LOS points.

Definition at line 337 of file [jurassic.h](#).

#### 4.3.2.2 double los\_t::z[NLOS]

Altitude [km].

Definition at line 340 of file [jurassic.h](#).

#### 4.3.2.3 double los\_t::lon[NLOS]

Longitude [deg].

Definition at line 343 of file [jurassic.h](#).

## 4.3.2.4 double los\_t::lat[NLOS]

Latitude [deg].

Definition at line 346 of file [jurassic.h](#).

## 4.3.2.5 double los\_t::p[NLOS]

Pressure [hPa].

Definition at line 349 of file [jurassic.h](#).

## 4.3.2.6 double los\_t::t[NLOS]

Temperature [K].

Definition at line 352 of file [jurassic.h](#).

## 4.3.2.7 double los\_t::q[NG][NLOS]

Volume mixing ratio.

Definition at line 355 of file [jurassic.h](#).

## 4.3.2.8 double los\_t::k[NW][NLOS]

Extinction [1/km].

Definition at line 358 of file [jurassic.h](#).

## 4.3.2.9 double los\_t::tsurf

Surface temperature [K].

Definition at line 361 of file [jurassic.h](#).

## 4.3.2.10 double los\_t::ds[NLOS]

Segment length [km].

Definition at line 364 of file [jurassic.h](#).

## 4.3.2.11 double los\_t::u[NG][NLOS]

Column density [molecules/cm<sup>2</sup>].

Definition at line 367 of file [jurassic.h](#).

The documentation for this struct was generated from the following file:

- [jurassic.h](#)

## 4.4 obs\_t Struct Reference

Observation geometry and radiance data.

```
#include <jurassic.h>
```

### Data Fields

- int [nr](#)  
*Number of ray paths.*
- double [time](#) [NR]  
*Time (seconds since 2000-01-01T00:00Z).*
- double [obsz](#) [NR]  
*Observer altitude [km].*
- double [obslon](#) [NR]  
*Observer longitude [deg].*
- double [obslat](#) [NR]  
*Observer latitude [deg].*
- double [vpz](#) [NR]  
*View point altitude [km].*
- double [vplon](#) [NR]  
*View point longitude [deg].*
- double [vplat](#) [NR]  
*View point latitude [deg].*
- double [tpz](#) [NR]  
*Tangent point altitude [km].*
- double [tplon](#) [NR]  
*Tangent point longitude [deg].*
- double [tplat](#) [NR]  
*Tangent point latitude [deg].*
- double [tau](#) [ND][NR]  
*Transmittance of ray path.*
- double [rad](#) [ND][NR]  
*Radiance [ $W/(m^2 sr cm^{-1})$ ].*

### 4.4.1 Detailed Description

Observation geometry and radiance data.

Definition at line 372 of file [jurassic.h](#).

### 4.4.2 Field Documentation

#### 4.4.2.1 int obs\_t::nr

Number of ray paths.

Definition at line 375 of file [jurassic.h](#).

#### 4.4.2.2 `double obs_t::time[NR]`

Time (seconds since 2000-01-01T00:00Z).

Definition at line 378 of file [jurassic.h](#).

#### 4.4.2.3 `double obs_t::obsz[NR]`

Observer altitude [km].

Definition at line 381 of file [jurassic.h](#).

#### 4.4.2.4 `double obs_t::obslon[NR]`

Observer longitude [deg].

Definition at line 384 of file [jurassic.h](#).

#### 4.4.2.5 `double obs_t::obslat[NR]`

Observer latitude [deg].

Definition at line 387 of file [jurassic.h](#).

#### 4.4.2.6 `double obs_t::vpz[NR]`

View point altitude [km].

Definition at line 390 of file [jurassic.h](#).

#### 4.4.2.7 `double obs_t::vplon[NR]`

View point longitude [deg].

Definition at line 393 of file [jurassic.h](#).

#### 4.4.2.8 `double obs_t::vplat[NR]`

View point latitude [deg].

Definition at line 396 of file [jurassic.h](#).

#### 4.4.2.9 `double obs_t::tpz[NR]`

Tangent point altitude [km].

Definition at line 399 of file [jurassic.h](#).

#### 4.4.2.10 `double obs_t::tpon[NR]`

Tangent point longitude [deg].

Definition at line 402 of file [jurassic.h](#).



#### 4.4.2.11 double obs\_t::tplat[NR]

Tangent point latitude [deg].

Definition at line 405 of file [jurassic.h](#).

#### 4.4.2.12 double obs\_t::tau[ND][NR]

Transmittance of ray path.

Definition at line 408 of file [jurassic.h](#).

#### 4.4.2.13 double obs\_t::rad[ND][NR]

Radiance [ $W/(m^2 \text{ sr cm}^{-1})$ ].

Definition at line 411 of file [jurassic.h](#).

The documentation for this struct was generated from the following file:

- [jurassic.h](#)

### 4.5 ret\_t Struct Reference

Retrieval control parameters.

#### Data Fields

- char [dir](#) [LEN]  
*Working directory.*
- int [kernel\\_recomp](#)  
*Recomputation of kernel matrix (number of iterations).*
- int [conv\\_itmax](#)  
*Maximum number of iterations.*
- double [conv\\_dmin](#)  
*Minimum normalized step size in state space.*
- int [err\\_ana](#)  
*Carry out error analysis (0=no, 1=yes).*
- double [err\\_formod](#) [ND]  
*Forward model error [%].*
- double [err\\_noise](#) [ND]  
*Noise error [ $W/(m^2 \text{ sr cm}^{-1})$ ].*
- double [err\\_press](#)  
*Pressure error [%].*
- double [err\\_press\\_cz](#)  
*Vertical correlation length for pressure error [km].*
- double [err\\_press\\_ch](#)  
*Horizontal correlation length for pressure error [km].*
- double [err\\_temp](#)  
*Temperature error [K].*

- double `err_temp_cz`  
*Vertical correlation length for temperature error [km].*
- double `err_temp_ch`  
*Horizontal correlation length for temperature error [km].*
- double `err_q` [NG]  
*Volume mixing ratio error [%].*
- double `err_q_cz` [NG]  
*Vertical correlation length for volume mixing ratio error [km].*
- double `err_q_ch` [NG]  
*Horizontal correlation length for volume mixing ratio error [km].*
- double `err_k` [NW]  
*Extinction error [1/km].*
- double `err_k_cz` [NW]  
*Vertical correlation length for extinction error [km].*
- double `err_k_ch` [NW]  
*Horizontal correlation length for extinction error [km].*

#### 4.5.1 Detailed Description

Retrieval control parameters.

Definition at line 32 of file [retrieval.c](#).

#### 4.5.2 Field Documentation

##### 4.5.2.1 `char ret_t::dir[LEN]`

Working directory.

Definition at line 35 of file [retrieval.c](#).

##### 4.5.2.2 `int ret_t::kernel_recomp`

Recomputation of kernel matrix (number of iterations).

Definition at line 38 of file [retrieval.c](#).

##### 4.5.2.3 `int ret_t::conv_itmax`

Maximum number of iterations.

Definition at line 41 of file [retrieval.c](#).

##### 4.5.2.4 `double ret_t::conv_dmin`

Minimum normalized step size in state space.

Definition at line 44 of file [retrieval.c](#).

#### 4.5.2.5 int ret\_t::err\_ana

Carry out error analysis (0=no, 1=yes).

Definition at line 47 of file [retrieval.c](#).

#### 4.5.2.6 double ret\_t::err\_formod[ND]

Forward model error [%].

Definition at line 50 of file [retrieval.c](#).

#### 4.5.2.7 double ret\_t::err\_noise[ND]

Noise error [ $W/(m^2 \text{ sr cm}^{-1})$ ].

Definition at line 53 of file [retrieval.c](#).

#### 4.5.2.8 double ret\_t::err\_press

Pressure error [%].

Definition at line 56 of file [retrieval.c](#).

#### 4.5.2.9 double ret\_t::err\_press\_cz

Vertical correlation length for pressure error [km].

Definition at line 59 of file [retrieval.c](#).

#### 4.5.2.10 double ret\_t::err\_press\_ch

Horizontal correlation length for pressure error [km].

Definition at line 62 of file [retrieval.c](#).

#### 4.5.2.11 double ret\_t::err\_temp

Temperature error [K].

Definition at line 65 of file [retrieval.c](#).

#### 4.5.2.12 double ret\_t::err\_temp\_cz

Vertical correlation length for temperature error [km].

Definition at line 68 of file [retrieval.c](#).

#### 4.5.2.13 double ret\_t::err\_temp\_ch

Horizontal correlation length for temperature error [km].

Definition at line 71 of file [retrieval.c](#).

#### 4.5.2.14 double ret\_t::err\_q[NG]

Volume mixing ratio error [%].

Definition at line 74 of file [retrieval.c](#).

#### 4.5.2.15 double ret\_t::err\_q\_cz[NG]

Vertical correlation length for volume mixing ratio error [km].

Definition at line 77 of file [retrieval.c](#).

#### 4.5.2.16 double ret\_t::err\_q\_ch[NG]

Horizontal correlation length for volume mixing ratio error [km].

Definition at line 80 of file [retrieval.c](#).

#### 4.5.2.17 double ret\_t::err\_k[NW]

Extinction error [1/km].

Definition at line 83 of file [retrieval.c](#).

#### 4.5.2.18 double ret\_t::err\_k\_cz[NW]

Vertical correlation length for extinction error [km].

Definition at line 86 of file [retrieval.c](#).

#### 4.5.2.19 double ret\_t::err\_k\_ch[NW]

Horizontal correlation length for extinction error [km].

Definition at line 89 of file [retrieval.c](#).

The documentation for this struct was generated from the following file:

- [retrieval.c](#)

## 4.6 tbl\_t Struct Reference

Emissivity look-up tables.

```
#include <jurassic.h>
```

## Data Fields

- int `np` [NG][ND]  
*Number of pressure levels.*
- int `nt` [NG][ND][TBLNP]  
*Number of temperatures.*
- int `nu` [NG][ND][TBLNP][TBLNT]  
*Number of column densities.*
- double `p` [NG][ND][TBLNP]  
*Pressure [hPa].*
- double `t` [NG][ND][TBLNP][TBLNT]  
*Temperature [K].*
- float `u` [NG][ND][TBLNP][TBLNT][TBLNU]  
*Column density [molecules/cm<sup>2</sup>].*
- float `eps` [NG][ND][TBLNP][TBLNT][TBLNU]  
*Emissivity.*
- double `st` [TBLNS]  
*Source function temperature [K].*
- double `sr` [ND][TBLNS]  
*Source function radiance [W/(m<sup>2</sup> sr cm<sup>-1</sup>)].*

### 4.6.1 Detailed Description

Emissivity look-up tables.

Definition at line 416 of file [jurassic.h](#).

### 4.6.2 Field Documentation

#### 4.6.2.1 int tbl\_t::np[NG][ND]

Number of pressure levels.

Definition at line 419 of file [jurassic.h](#).

#### 4.6.2.2 int tbl\_t::nt[NG][ND][TBLNP]

Number of temperatures.

Definition at line 422 of file [jurassic.h](#).

#### 4.6.2.3 int tbl\_t::nu[NG][ND][TBLNP][TBLNT]

Number of column densities.

Definition at line 425 of file [jurassic.h](#).

4.6.2.4 `double tbl_t::p[NG][ND][TBLNP]`

Pressure [hPa].

Definition at line 428 of file [jurassic.h](#).

4.6.2.5 `double tbl_t::t[NG][ND][TBLNP][TBLNT]`

Temperature [K].

Definition at line 431 of file [jurassic.h](#).

4.6.2.6 `float tbl_t::u[NG][ND][TBLNP][TBLNT][TBLNU]`

Column density [molecules/cm<sup>2</sup>].

Definition at line 434 of file [jurassic.h](#).

4.6.2.7 `float tbl_t::eps[NG][ND][TBLNP][TBLNT][TBLNU]`

Emissivity.

Definition at line 437 of file [jurassic.h](#).

4.6.2.8 `double tbl_t::st[TBLNS]`

Source function temperature [K].

Definition at line 440 of file [jurassic.h](#).

4.6.2.9 `double tbl_t::sr[ND][TBLNS]`

Source function radiance [W/(m<sup>2</sup> sr cm<sup>-1</sup>)].

Definition at line 443 of file [jurassic.h](#).

The documentation for this struct was generated from the following file:

- [jurassic.h](#)

## 5 File Documentation

### 5.1 brightness.c File Reference

Convert radiance to brightness temperature.

#### Functions

- `int main (int argc, char *argv[ ])`

### 5.1.1 Detailed Description

Convert radiance to brightness temperature.

Definition in file [brightness.c](#).

### 5.1.2 Function Documentation

#### 5.1.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file [brightness.c](#).

```

00029         {
00030
00031     double nu, rad;
00032
00033     /* Check arguments... */
00034     if (argc < 3)
00035         ERRMSG("Give parameters: <rad> <nu>");
00036
00037     /* Read arguments... */
00038     rad = atof(argv[1]);
00039     nu = atof(argv[2]);
00040
00041     /* Compute brightness temperature... */
00042     printf("%.10g\n", brightness(rad, nu));
00043
00044     return EXIT_SUCCESS;
00045 }
```

Here is the call graph for this function:



## 5.2 brightness.c

```

00001 /*
00002  This file is part of JURASSIC.
00003
00004  JURASSIC is free software: you can redistribute it and/or modify
00005  it under the terms of the GNU General Public License as published by
00006  the Free Software Foundation, either version 3 of the License, or
00007  (at your option) any later version.
00008
00009  JURASSIC is distributed in the hope that it will be useful,
00010  but WITHOUT ANY WARRANTY; without even the implied warranty of
00011  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012  GNU General Public License for more details.
00013
00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
```

```

00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     double nu, rad;
00032
00033     /* Check arguments... */
00034     if (argc < 3)
00035         ERRMSG("Give parameters: <rad> <nu>");
00036
00037     /* Read arguments... */
00038     rad = atof(argv[1]);
00039     nu = atof(argv[2]);
00040
00041     /* Compute brightness temperature... */
00042     printf("%.10g\n", brightness(rad, nu));
00043
00044     return EXIT_SUCCESS;
00045 }

```

## 5.3 climatology.c File Reference

Prepare atmospheric data file from climatological data.

### Functions

- `int main (int argc, char *argv[])`

#### 5.3.1 Detailed Description

Prepare atmospheric data file from climatological data.

Definition in file [climatology.c](#).

#### 5.3.2 Function Documentation

##### 5.3.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file [climatology.c](#).

```

00029     {
00030
00031     static atm_t atm;
00032     static ctl_t ctl;
00033
00034     double dz, t0, z, z0, z1;
00035
00036     /* Check arguments... */
00037     if (argc < 3)
00038         ERRMSG("Give parameters: <ctl> <atm>");
00039
00040     /* Read control parameters... */
00041     read_ctl(argc, argv, &ctl);
00042     t0 = scan_ctl(argc, argv, "T0", -1, "0", NULL);
00043     z0 = scan_ctl(argc, argv, "Z0", -1, "0", NULL);
00044     z1 = scan_ctl(argc, argv, "Z1", -1, "90", NULL);
00045     dz = scan_ctl(argc, argv, "DZ", -1, "1", NULL);
00046
00047     /* Set atmospheric grid... */
00048     for (z = z0; z <= z1; z += dz) {
00049         atm.time[atm.np] = t0;
00050         atm.z[atm.np] = z;
00051         if (++atm.np >= NP)
00052             ERRMSG("Too many atmospheric grid points!");
00053     }

```

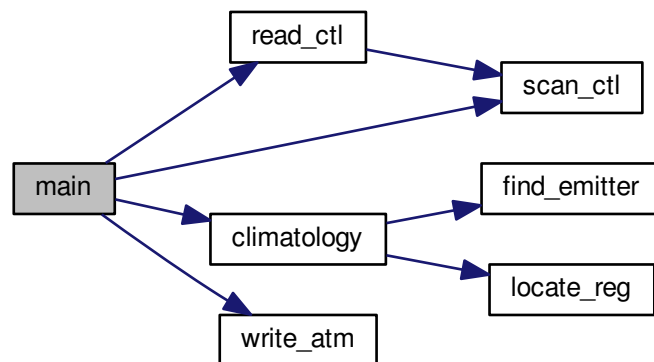


```

00054
00055  /* Interpolate climatological data... */
00056  climatology(&ctl, &atm);
00057
00058  /* Write data to disk... */
00059  write_atm(NULL, argv[2], &ctl, &atm);
00060
00061  return EXIT_SUCCESS;
00062 }

```

Here is the call graph for this function:



## 5.4 climatology.c

```

00001  /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018  */
00019
00025  #include "jurassic.h"
00026
00027  int main(
00028      int argc,
00029      char *argv[]) {
00030
00031      static atm_t atm;
00032      static ctl_t ctl;
00033
00034      double dz, t0, z, z0, z1;
00035
00036      /* Check arguments... */
00037      if (argc < 3)
00038          ERRMSG("Give parameters: <ctl> <atm>");
00039
00040      /* Read control parameters... */
00041      read_ctl(argc, argv, &ctl);
00042      t0 = scan_ctl(argc, argv, "T0", -1, "0", NULL);

```

```

00043     z0 = scan_ctl(argc, argv, "Z0", -1, "0", NULL);
00044     z1 = scan_ctl(argc, argv, "Z1", -1, "90", NULL);
00045     dz = scan_ctl(argc, argv, "DZ", -1, "1", NULL);
00046
00047     /* Set atmospheric grid... */
00048     for (z = z0; z <= z1; z += dz) {
00049         atm.time[atm.np] = t0;
00050         atm.z[atm.np] = z;
00051         if ((++atm.np) >= NP)
00052             ERRMSG("Too many atmospheric grid points!");
00053     }
00054
00055     /* Interpolate climatological data... */
00056     climatology(&ctl, &atm);
00057
00058     /* Write data to disk... */
00059     write_atm(NULL, argv[2], &ctl, &atm);
00060
00061     return EXIT_SUCCESS;
00062 }

```

## 5.5 formod.c File Reference

JURASSIC forward model.

### Functions

- void [call\\_formod](#) ([ctl\\_t](#) \*ctl, const char \*wrkdir, const char \*obsfile, const char \*atmfile, const char \*radfile, const char \*task)  
*Perform forward model calculations in a single directory.*
- int [main](#) (int argc, char \*argv[])

### 5.5.1 Detailed Description

JURASSIC forward model.

Definition in file [formod.c](#).

### 5.5.2 Function Documentation

**5.5.2.1** void [call\\_formod](#) ( [ctl\\_t](#) \* *ctl*, const char \* *wrkdir*, const char \* *obsfile*, const char \* *atmfile*, const char \* *radfile*, const char \* *task* )

Perform forward model calculations in a single directory.

Definition at line 97 of file [formod.c](#).

```

00103     {
00104
00105     static atm_t atm, atm2;
00106     static obs_t obs, obs2;
00107
00108     char filename[LEN];
00109
00110     int id, ig, ig2, ip, ir, iw;
00111
00112     /* Read observation geometry... */
00113     read_obs(wrkdir, obsfile, ctl, &obs);
00114
00115     /* Read atmospheric data... */
00116     read_atm(wrkdir, atmfile, ctl, &atm);
00117

```

```

00118  /* Compute multiple profiles... */
00119  if (task[0] == 'p' || task[0] == 'P') {
00120
00121      /* Loop over ray paths... */
00122      for (ir = 0; ir < obs.nr; ir++) {
00123
00124          /* Get atmospheric data... */
00125          atm2.np = 0;
00126          for (ip = 0; ip < atm.np; ip++)
00127              if (atm.time[ip] == obs.time[ir]) {
00128                  atm2.time[atm2.np] = atm.time[ip];
00129                  atm2.z[atm2.np] = atm.z[ip];
00130                  atm2.lon[atm2.np] = atm.lon[ip];
00131                  atm2.lat[atm2.np] = atm.lat[ip];
00132                  atm2.p[atm2.np] = atm.p[ip];
00133                  atm2.t[atm2.np] = atm.t[ip];
00134                  for (ig = 0; ig < ctl->ng; ig++)
00135                      atm2.q[ig][atm2.np] = atm.q[ig][ip];
00136                  for (iw = 0; iw < ctl->nw; iw++)
00137                      atm2.k[iw][atm2.np] = atm.k[iw][ip];
00138                  atm2.np++;
00139              }
00140
00141          /* Get observation data... */
00142          obs2.nr = 1;
00143          obs2.time[0] = obs.time[ir];
00144          obs2.vpz[0] = obs.vpz[ir];
00145          obs2.vplon[0] = obs.vplon[ir];
00146          obs2.vplat[0] = obs.vplat[ir];
00147          obs2.obsz[0] = obs.obsz[ir];
00148          obs2.obslon[0] = obs.obslon[ir];
00149          obs2.obslat[0] = obs.obslat[ir];
00150
00151          /* Check number of data points... */
00152          if (atm2.np > 0) {
00153
00154              /* Call forward model... */
00155              formod(ctl, &atm2, &obs2);
00156
00157              /* Save radiance data... */
00158              for (id = 0; id < ctl->nd; id++) {
00159                  obs.rad[id][ir] = obs2.rad[id][0];
00160                  obs.tau[id][ir] = obs2.tau[id][0];
00161              }
00162          }
00163      }
00164
00165      /* Write radiance data... */
00166      write_obs(wrkdir, radfile, ctl, &obs);
00167  }
00168
00169  /* Compute single profile... */
00170  else {
00171
00172      /* Call forward model... */
00173      formod(ctl, &atm, &obs);
00174
00175      /* Save radiance data... */
00176      write_obs(wrkdir, radfile, ctl, &obs);
00177
00178      /* Compute contributions... */
00179      if (task[0] == 'c' || task[0] == 'C') {
00180
00181          /* Switch off continua... */
00182          ctl->ctm_co2 = 0;
00183          ctl->ctm_h2o = 0;
00184          ctl->ctm_n2 = 0;
00185          ctl->ctm_o2 = 0;
00186
00187          /* Loop over emitters... */
00188          for (ig = 0; ig < ctl->ng; ig++) {
00189
00190              /* Copy atmospheric data... */
00191              copy_atm(ctl, &atm2, &atm, 0);
00192
00193              /* Set extinction to zero... */
00194              for (iw = 0; iw < ctl->nw; iw++)
00195                  for (ip = 0; ip < atm2.np; ip++)
00196                      atm2.k[iw][ip] = 0;
00197
00198              /* Set volume mixing ratios to zero... */
00199              for (ig2 = 0; ig2 < ctl->ng; ig2++)
00200                  if (ig2 != ig)
00201                      for (ip = 0; ip < atm2.np; ip++)
00202                          atm2.q[ig2][ip] = 0;
00203
00204              /* Call forward model... */

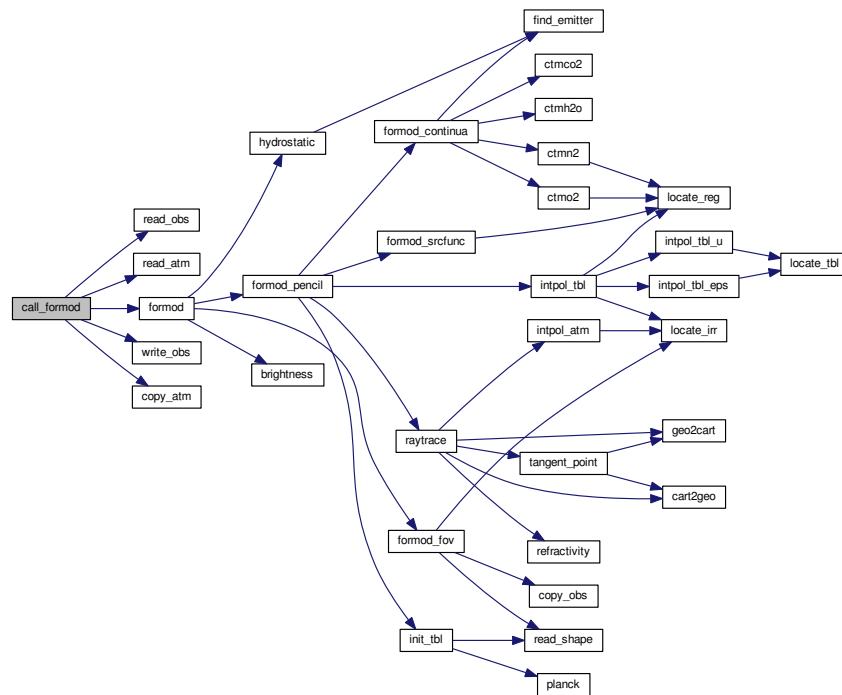
```

```

00205     formod(ctl, &atm2, &obs);
00206
00207     /* Save radiance data... */
00208     sprintf(filename, "%s.%s", radfile, ctl->emitter[ig]);
00209     write_obs(wrkdir, filename, ctl, &obs);
00210 }
00211
00212 /* Copy atmospheric data... */
00213 copy_atm(ctl, &atm2, &atm, 0);
00214
00215 /* Set volume mixing ratios to zero... */
00216 for (ig = 0; ig < ctl->ng; ig++)
00217     for (ip = 0; ip < atm2.np; ip++)
00218         atm2.q[ig][ip] = 0;
00219
00220 /* Call forward model... */
00221 formod(ctl, &atm2, &obs);
00222
00223 /* Save radiance data... */
00224 sprintf(filename, "%s.EXTINCT", radfile);
00225 write_obs(wrkdir, filename, ctl, &obs);
00226 }
00227
00228 /* Measure CPU-time... */
00229 if (task[0] == 't' || task[0] == 'T') {
00230     TIMER("formod", 1);
00231     formod(ctl, &atm, &obs);
00232     TIMER("formod", 3);
00233 }
00234 }
00235 }

```

Here is the call graph for this function:



### 5.5.2.2 int main ( int argc, char \* argv[] )

Definition at line 44 of file [formod.c](#).

```

00046     {

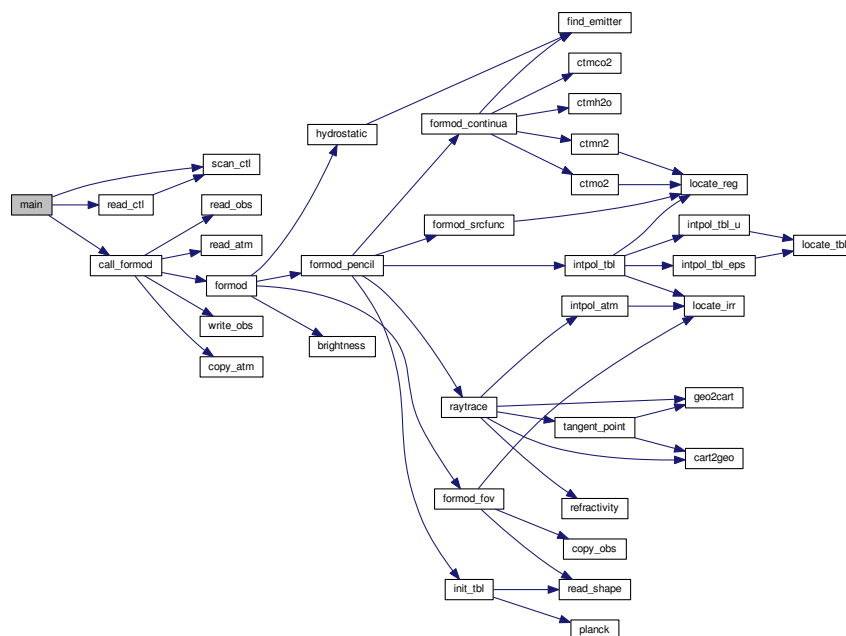
```

```

00047
00048 static ctl_t ctl;
00049
00050 FILE *in;
00051
00052 char dirlist[LEN], task[LEN], wrkdir[LEN];
00053
00054 /* Check arguments... */
00055 if (argc < 5)
00056     ERRMSG("Give parameters: <ctl> <obs> <atm> <rad>");
00057
00058 /* Read control parameters... */
00059 read_ctl(argc, argv, &ctl);
00060
00061 /* Get task... */
00062 scan_ctl(argc, argv, "TASK", -1, "-", task);
00063
00064 /* Get dirlist... */
00065 scan_ctl(argc, argv, "DIRLIST", -1, "-", dirlist);
00066
00067 /* Single forward calculation... */
00068 if (dirlist[0] == '-')
00069     call_formod(&ctl, NULL, argv[2], argv[3], argv[4], task);
00070
00071 /* Work on directory list... */
00072 else {
00073
00074     /* Open directory list... */
00075     if (!(in = fopen(dirlist, "r")))
00076         ERRMSG("Cannot open directory list!");
00077
00078     /* Loop over directories... */
00079     while (fscanf(in, "%s", wrkdir) != EOF) {
00080
00081         /* Write info... */
00082         printf("\nWorking directory: %s\n", wrkdir);
00083
00084         /* Call forward model... */
00085         call_formod(&ctl, wrkdir, argv[2], argv[3], argv[4], task);
00086     }
00087
00088     /* Close dirlist... */
00089     fclose(in);
00090 }
00091
00092 return EXIT_SUCCESS;
00093 }

```

Here is the call graph for this function:



## 5.6 formod.c

```

00001 /*
00002  This file is part of JURASSIC.
00003
00004  JURASSIC is free software: you can redistribute it and/or modify
00005  it under the terms of the GNU General Public License as published by
00006  the Free Software Foundation, either version 3 of the License, or
00007  (at your option) any later version.
00008
00009  JURASSIC is distributed in the hope that it will be useful,
00010  but WITHOUT ANY WARRANTY; without even the implied warranty of
00011  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012  GNU General Public License for more details.
00013
00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /* -----
00028  Functions...
00029  ----- */
00030
00032 void call_formod(
00033     ctl_t * ctl,
00034     const char *wrkdir,
00035     const char *obsfile,
00036     const char *atmfile,
00037     const char *radfile,
00038     const char *task);
00039
00040 /* -----
00041  Main...
00042  ----- */
00043
00044 int main(
00045     int argc,
00046     char *argv[]) {
00047
00048     static ctl_t ctl;
00049
00050     FILE *in;
00051
00052     char dirlist[LEN], task[LEN], wrkdir[LEN];
00053
00054     /* Check arguments... */
00055     if (argc < 5)
00056         ERRMSG("Give parameters: <ctl> <obs> <atm> <rad>");
00057
00058     /* Read control parameters... */
00059     read_ctl(argc, argv, &ctl);
00060
00061     /* Get task... */
00062     scan_ctl(argc, argv, "TASK", -1, "-", task);
00063
00064     /* Get dirlist... */
00065     scan_ctl(argc, argv, "DIRLIST", -1, "-", dirlist);
00066
00067     /* Single forward calculation... */
00068     if (dirlist[0] == '-')
00069         call_formod(&ctl, NULL, argv[2], argv[3], argv[4], task);
00070
00071     /* Work on directory list... */
00072     else {
00073
00074         /* Open directory list... */
00075         if (!(in = fopen(dirlist, "r")))
00076             ERRMSG("Cannot open directory list!");
00077
00078         /* Loop over directories... */
00079         while (fscanf(in, "%s", wrkdir) != EOF) {
00080
00081             /* Write info... */
00082             printf("\nWorking directory: %s\n", wrkdir);
00083
00084             /* Call forward model... */
00085             call_formod(&ctl, wrkdir, argv[2], argv[3], argv[4], task);
00086         }
00087
00088         /* Close dirlist... */
00089         fclose(in);
00090     }

```

```

00091
00092     return EXIT_SUCCESS;
00093 }
00094
00095 /*****
00096
00097 void call_formod(
00098     ctl_t * ctl,
00099     const char *wrkdir,
00100     const char *obsfile,
00101     const char *atmfile,
00102     const char *radfile,
00103     const char *task) {
00104
00105     static atm_t atm, atm2;
00106     static obs_t obs, obs2;
00107
00108     char filename[LEN];
00109
00110     int id, ig, ig2, ip, ir, iw;
00111
00112     /* Read observation geometry... */
00113     read_obs(wrkdir, obsfile, ctl, &obs);
00114
00115     /* Read atmospheric data... */
00116     read_atm(wrkdir, atmfile, ctl, &atm);
00117
00118     /* Compute multiple profiles... */
00119     if (task[0] == 'p' || task[0] == 'P') {
00120
00121         /* Loop over ray paths... */
00122         for (ir = 0; ir < obs.nr; ir++) {
00123
00124             /* Get atmospheric data... */
00125             atm2.np = 0;
00126             for (ip = 0; ip < atm.np; ip++)
00127                 if (atm.time[ip] == obs.time[ir]) {
00128                     atm2.time[atm2.np] = atm.time[ip];
00129                     atm2.z[atm2.np] = atm.z[ip];
00130                     atm2.lon[atm2.np] = atm.lon[ip];
00131                     atm2.lat[atm2.np] = atm.lat[ip];
00132                     atm2.p[atm2.np] = atm.p[ip];
00133                     atm2.t[atm2.np] = atm.t[ip];
00134                     for (ig = 0; ig < ctl->ng; ig++)
00135                         atm2.q[ig][atm2.np] = atm.q[ig][ip];
00136                     for (iw = 0; iw < ctl->nw; iw++)
00137                         atm2.k[iw][atm2.np] = atm.k[iw][ip];
00138                     atm2.np++;
00139                 }
00140
00141             /* Get observation data... */
00142             obs2.nr = 1;
00143             obs2.time[0] = obs.time[ir];
00144             obs2.vpz[0] = obs.vpz[ir];
00145             obs2.vplon[0] = obs.vplon[ir];
00146             obs2.vplat[0] = obs.vplat[ir];
00147             obs2.obsz[0] = obs.obsz[ir];
00148             obs2.obslon[0] = obs.obslon[ir];
00149             obs2.obslat[0] = obs.obslat[ir];
00150
00151             /* Check number of data points... */
00152             if (atm2.np > 0) {
00153
00154                 /* Call forward model... */
00155                 formod(ctl, &atm2, &obs2);
00156
00157                 /* Save radiance data... */
00158                 for (id = 0; id < ctl->nd; id++) {
00159                     obs.rad[id][ir] = obs2.rad[id][0];
00160                     obs.tau[id][ir] = obs2.tau[id][0];
00161                 }
00162             }
00163         }
00164
00165         /* Write radiance data... */
00166         write_obs(wrkdir, radfile, ctl, &obs);
00167     }
00168
00169     /* Compute single profile... */
00170     else {
00171
00172         /* Call forward model... */
00173         formod(ctl, &atm, &obs);
00174
00175         /* Save radiance data... */
00176         write_obs(wrkdir, radfile, ctl, &obs);
00177     }

```

```

00178      /* Compute contributions... */
00179      if (task[0] == 'c' || task[0] == 'C') {
00180
00181          /* Switch off continua... */
00182          ctl->ctm_co2 = 0;
00183          ctl->ctm_h2o = 0;
00184          ctl->ctm_n2 = 0;
00185          ctl->ctm_o2 = 0;
00186
00187          /* Loop over emitters... */
00188          for (ig = 0; ig < ctl->ng; ig++) {
00189
00190              /* Copy atmospheric data... */
00191              copy_atm(ctl, &atm2, &atm, 0);
00192
00193              /* Set extinction to zero... */
00194              for (iw = 0; iw < ctl->nw; iw++)
00195                  for (ip = 0; ip < atm2.np; ip++)
00196                      atm2.k[iw][ip] = 0;
00197
00198              /* Set volume mixing ratios to zero... */
00199              for (ig2 = 0; ig2 < ctl->ng; ig2++)
00200                  if (ig2 != ig)
00201                      for (ip = 0; ip < atm2.np; ip++)
00202                          atm2.q[ig2][ip] = 0;
00203
00204              /* Call forward model... */
00205              formod(ctl, &atm2, &obs);
00206
00207              /* Save radiance data... */
00208              sprintf(filename, "%s.%s", radfile, ctl->emitter[ig]);
00209              write_obs(wrkdir, filename, ctl, &obs);
00210          }
00211
00212          /* Copy atmospheric data... */
00213          copy_atm(ctl, &atm2, &atm, 0);
00214
00215          /* Set volume mixing ratios to zero... */
00216          for (ig = 0; ig < ctl->ng; ig++)
00217              for (ip = 0; ip < atm2.np; ip++)
00218                  atm2.q[ig][ip] = 0;
00219
00220          /* Call forward model... */
00221          formod(ctl, &atm2, &obs);
00222
00223          /* Save radiance data... */
00224          sprintf(filename, "%s.EXTINCT", radfile);
00225          write_obs(wrkdir, filename, ctl, &obs);
00226      }
00227
00228      /* Measure CPU-time... */
00229      if (task[0] == 't' || task[0] == 'T') {
00230          TIMER("formod", 1);
00231          formod(ctl, &atm, &obs);
00232          TIMER("formod", 3);
00233      }
00234  }
00235  }

```

## 5.7 hydrostatic.c File Reference

Recalculate pressure based on hydrostatic equilibrium.

### Functions

- int [main](#) (int argc, char \*argv[])

#### 5.7.1 Detailed Description

Recalculate pressure based on hydrostatic equilibrium.

Definition in file [hydrostatic.c](#).



## 5.7.2 Function Documentation

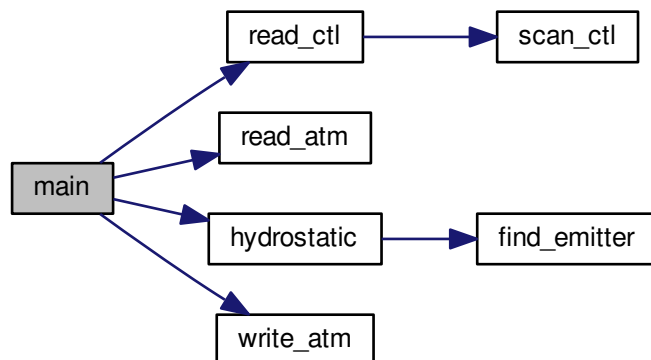
### 5.7.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file [hydrostatic.c](#).

```

00029         {
00030
00031     static atm_t atm;
00032     static ctl_t ctl;
00033
00034     /* Check arguments... */
00035     if (argc < 4)
00036         ERRMSG("Give parameters: <ctl> <atm_in> <atm_hyd>");
00037
00038     /* Read control parameters... */
00039     read_ctl(argc, argv, &ctl);
00040
00041     /* Check reference height... */
00042     if (ctl.hydz < 0)
00043         ERRMSG("Set HYDZ>=0!");
00044
00045     /* Read atmospheric data... */
00046     read_atm(NULL, argv[2], &ctl, &atm);
00047
00048     /* Build atmosphere based on hydrostatic equilibrium... */
00049     hydrostatic(&ctl, &atm);
00050
00051     /* Write atmospheric data... */
00052     write_atm(NULL, argv[3], &ctl, &atm);
00053
00054     return EXIT_SUCCESS;
00055 }
```

Here is the call graph for this function:



## 5.8 hydrostatic.c

```

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00008
```

```

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00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     static atm_t atm;
00032     static ctl_t ctl;
00033
00034     /* Check arguments... */
00035     if (argc < 4)
00036         ERRMSG("Give parameters: <ctl> <atm_in> <atm_hyd>");
00037
00038     /* Read control parameters... */
00039     read_ctl(argc, argv, &ctl);
00040
00041     /* Check reference height... */
00042     if (ctl.hydz < 0)
00043         ERRMSG("Set HYDZ>=0!");
00044
00045     /* Read atmospheric data... */
00046     read_atm(NULL, argv[2], &ctl, &atm);
00047
00048     /* Build atmosphere based on hydrostatic equilibrium... */
00049     hydrostatic(&ctl, &atm);
00050
00051     /* Write atmospheric data... */
00052     write_atm(NULL, argv[3], &ctl, &atm);
00053
00054     return EXIT_SUCCESS;
00055 }

```

## 5.9 interpolate.c File Reference

Interpolate atmospheric data to another spatial grid.

### Functions

- int [main](#) (int argc, char \*argv[])

#### 5.9.1 Detailed Description

Interpolate atmospheric data to another spatial grid.

Definition in file [interpolate.c](#).

#### 5.9.2 Function Documentation

##### 5.9.2.1 int main ( int argc, char \* argv[] )

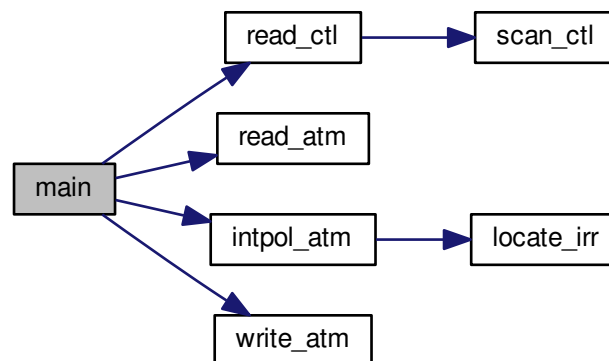
Definition at line 27 of file [interpolate.c](#).

```

00029         {
00030
00031     static atm_t atm_in, atm_pts;
00032     static ctl_t ctl;
00033
00034     double k[NW], q[NG];
00035
00036     int ig, ip, iw;
00037
00038     /* Interpolate atmospheric data... */
00039
00040     /* Check arguments... */
00041     if (argc < 5)
00042         ERRMSG("Give parameters: <ctl> <atm_in> <atm_pts> <atm_out>");
00043
00044     /* Read control parameters... */
00045     read_ctl(argc, argv, &ctl);
00046
00047     /* Read atmospheric data... */
00048     read_atm(NULL, argv[2], &ctl, &atm_in);
00049     read_atm(NULL, argv[3], &ctl, &atm_pts);
00050
00051     /* Interpolate atmospheric data... */
00052     for (ip = 0; ip < atm_pts.np; ip++) {
00053         intpol_atm(&ctl, &atm_in, atm_pts.z[ip],
00054                 &atm_pts.p[ip], &atm_pts.t[ip], q, k);
00055         for (ig = 0; ig < ctl.ng; ig++)
00056             atm_pts.q[ig][ip] = q[ig];
00057         for (iw = 0; iw < ctl.nw; iw++)
00058             atm_pts.k[iw][ip] = k[iw];
00059     }
00060
00061     /* Save interpolated data... */
00062     write_atm(NULL, argv[4], &ctl, &atm_pts);
00063
00064     return EXIT_SUCCESS;
00065 }

```

Here is the call graph for this function:



## 5.10 interpolate.c

```

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00008
00009     JURASSIC is distributed in the hope that it will be useful,

```

```

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00015 along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017 Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     static atm_t atm_in, atm_pts;
00032     static ctl_t ctl;
00033
00034     double k[NW], q[NG];
00035
00036     int ig, ip, iw;
00037
00038     /* Interpolate atmospheric data... */
00039
00040     /* Check arguments... */
00041     if (argc < 5)
00042         ERRMSG("Give parameters: <ctl> <atm_in> <atm_pts> <atm_out>");
00043
00044     /* Read control parameters... */
00045     read_ctl(argc, argv, &ctl);
00046
00047     /* Read atmospheric data... */
00048     read_atm(NULL, argv[2], &ctl, &atm_in);
00049     read_atm(NULL, argv[3], &ctl, &atm_pts);
00050
00051     /* Interpolate atmospheric data... */
00052     for (ip = 0; ip < atm_pts.np; ip++) {
00053         intpol_atm(&ctl, &atm_in, atm_pts.z[ip],
00054                 &atm_pts.p[ip], &atm_pts.t[ip], q, k);
00055         for (ig = 0; ig < ctl.ng; ig++)
00056             atm_pts.q[ig][ip] = q[ig];
00057         for (iw = 0; iw < ctl.nw; iw++)
00058             atm_pts.k[iw][ip] = k[iw];
00059     }
00060
00061     /* Save interpolated data... */
00062     write_atm(NULL, argv[4], &ctl, &atm_pts);
00063
00064     return EXIT_SUCCESS;
00065 }

```

## 5.11 jsec2time.c File Reference

Convert Julian seconds to date.

### Functions

- int [main](#) (int argc, char \*argv[])

#### 5.11.1 Detailed Description

Convert Julian seconds to date.

Definition in file [jsec2time.c](#).

### 5.11.2 Function Documentation

#### 5.11.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file `jsec2time.c`.

```

00029         {
00030
00031     double jsec, remain;
00032
00033     int day, hour, min, mon, sec, year;
00034
00035     /* Check arguments... */
00036     if (argc < 2)
00037         ERRMSG("Give parameters: <jsec>");
00038
00039     /* Read arguments... */
00040     jsec = atof(argv[1]);
00041
00042     /* Convert time... */
00043     jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044     printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046     return EXIT_SUCCESS;
00047 }

```

Here is the call graph for this function:



## 5.12 `jsec2time.c`

```

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00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     double jsec, remain;
00032
00033     int day, hour, min, mon, sec, year;
00034
00035     /* Check arguments... */

```

```

00036  if (argc < 2)
00037      ERRMSG("Give parameters: <jsec>");
00038
00039  /* Read arguments... */
00040  jsec = atof(argv[1]);
00041
00042  /* Convert time... */
00043  jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044  printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046  return EXIT_SUCCESS;
00047 }

```

## 5.13 jurassic.c File Reference

JURASSIC library definitions.

### Functions

- `size_t atm2x (ctl_t *ctl, atm_t *atm, gsl_vector *x, int *iqa, int *ipa)`  
*Compose state vector or parameter vector.*
- `void atm2x_help (atm_t *atm, double zmin, double zmax, double *value, int val_iqa, gsl_vector *x, int *iqa, int *ipa, size_t *n)`  
*Add elements to state vector.*
- `double brightness (double rad, double nu)`  
*Compute brightness temperature.*
- `void cart2geo (double *x, double *z, double *lon, double *lat)`  
*Convert Cartesian coordinates to geolocation.*
- `void climatology (ctl_t *ctl, atm_t *atm)`  
*Interpolate climatological data.*
- `double ctmc02 (double nu, double p, double t, double u)`  
*Compute carbon dioxide continuum (optical depth).*
- `double ctmh2o (double nu, double p, double t, double q, double u)`  
*Compute water vapor continuum (optical depth).*
- `double ctmn2 (double nu, double p, double t)`  
*Compute nitrogen continuum (absorption coefficient).*
- `double ctmo2 (double nu, double p, double t)`  
*Compute oxygen continuum (absorption coefficient).*
- `void copy_atm (ctl_t *ctl, atm_t *atm_dest, atm_t *atm_src, int init)`  
*Copy and initialize atmospheric data.*
- `void copy_obs (ctl_t *ctl, obs_t *obs_dest, obs_t *obs_src, int init)`  
*Copy and initialize observation data.*
- `int find_emitter (ctl_t *ctl, const char *emitter)`  
*Find index of an emitter.*
- `void formod (ctl_t *ctl, atm_t *atm, obs_t *obs)`  
*Determine ray paths and compute radiative transfer.*
- `void formod_continua (ctl_t *ctl, los_t *los, int ip, double *beta)`  
*Compute absorption coefficient of continua.*
- `void formod_fov (ctl_t *ctl, obs_t *obs)`  
*Apply field of view convolution.*
- `void formod_pencil (ctl_t *ctl, atm_t *atm, obs_t *obs, int ir)`  
*Compute radiative transfer for a pencil beam.*
- `void formod_srcfunc (ctl_t *ctl, tbl_t *tbl, double t, double *src)`  
*Compute Planck source function.*

- void `geo2cart` (double z, double lon, double lat, double \*x)  
*Convert geolocation to Cartesian coordinates.*
- void `hydrostatic` (`ctl_t` \*ctl, `atm_t` \*atm)  
*Set hydrostatic equilibrium.*
- void `idx2name` (`ctl_t` \*ctl, int idx, char \*quantity)  
*Determine name of state vector quantity for given index.*
- void `init_tbl` (`ctl_t` \*ctl, `tbl_t` \*tbl)  
*Initialize look-up tables.*
- void `intpol_atm` (`ctl_t` \*ctl, `atm_t` \*atm, double z, double \*p, double \*t, double \*q, double \*k)  
*Interpolate atmospheric data.*
- void `intpol_tbl` (`ctl_t` \*ctl, `tbl_t` \*tbl, `los_t` \*los, int ip, double tau\_path[NG][ND], double tau\_seg[ND])  
*Get transmittance from look-up tables.*
- double `intpol_tbl_eps` (`tbl_t` \*tbl, int ig, int id, int ip, int it, double u)  
*Interpolate emissivity from look-up tables.*
- double `intpol_tbl_u` (`tbl_t` \*tbl, int ig, int id, int ip, int it, double eps)  
*Interpolate column density from look-up tables.*
- void `jsec2time` (double jsec, int \*year, int \*mon, int \*day, int \*hour, int \*min, int \*sec, double \*remain)  
*Convert seconds to date.*
- void `kernel` (`ctl_t` \*ctl, `atm_t` \*atm, `obs_t` \*obs, gsl\_matrix \*k)  
*Compute Jacobians.*
- int `locate_irr` (double \*xx, int n, double x)  
*Find array index for irregular grid.*
- int `locate_reg` (double \*xx, int n, double x)  
*Find array index for regular grid.*
- int `locate_tbl` (float \*xx, int n, double x)  
*Find array index in float array.*
- size\_t `obs2y` (`ctl_t` \*ctl, `obs_t` \*obs, gsl\_vector \*y, int \*ida, int \*ira)  
*Compose measurement vector.*
- double `planck` (double t, double nu)  
*Compute Planck function.*
- void `raytrace` (`ctl_t` \*ctl, `atm_t` \*atm, `obs_t` \*obs, `los_t` \*los, int ir)  
*Do ray-tracing to determine LOS.*
- void `read_atm` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `atm_t` \*atm)  
*Read atmospheric data.*
- void `read_ctl` (int argc, char \*argv[], `ctl_t` \*ctl)  
*Read forward model control parameters.*
- void `read_matrix` (const char \*dirname, const char \*filename, gsl\_matrix \*matrix)  
*Read matrix.*
- void `read_obs` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `obs_t` \*obs)  
*Read observation data.*
- void `read_shape` (const char \*filename, double \*x, double \*y, int \*n)  
*Read shape function.*
- double `refractivity` (double p, double t)  
*Compute refractivity (return value is n - 1).*
- double `scan_ctl` (int argc, char \*argv[], const char \*varname, int arridx, const char \*defvalue, char \*value)  
*Search control parameter file for variable entry.*
- void `tangent_point` (`los_t` \*los, double \*tpz, double \*tplon, double \*tplat)  
*Find tangent point of a given LOS.*
- void `time2jsec` (int year, int mon, int day, int hour, int min, int sec, double remain, double \*jsec)  
*Convert date to seconds.*
- void `timer` (const char \*name, const char \*file, const char \*func, int line, int mode)

*Measure wall-clock time.*

- void [write\\_atm](#) (const char \*dirname, const char \*filename, [ctl\\_t](#) \*ctl, [atm\\_t](#) \*atm)

*Write atmospheric data.*

- void [write\\_matrix](#) (const char \*dirname, const char \*filename, [ctl\\_t](#) \*ctl, [gsl\\_matrix](#) \*matrix, [atm\\_t](#) \*atm, [obs\\_t](#) \*obs, const char \*rowSpace, const char \*colSpace, const char \*sort)

*Write matrix.*

- void [write\\_obs](#) (const char \*dirname, const char \*filename, [ctl\\_t](#) \*ctl, [obs\\_t](#) \*obs)

*Write observation data.*

- void [x2atm](#) ([ctl\\_t](#) \*ctl, [gsl\\_vector](#) \*x, [atm\\_t](#) \*atm)

*Decompose parameter vector or state vector.*

- void [x2atm\\_help](#) ([atm\\_t](#) \*atm, double zmin, double zmax, double \*value, [gsl\\_vector](#) \*x, [size\\_t](#) \*n)

*Extract elements from state vector.*

- void [y2obs](#) ([ctl\\_t](#) \*ctl, [gsl\\_vector](#) \*y, [obs\\_t](#) \*obs)

*Decompose measurement vector.*

### 5.13.1 Detailed Description

JURASSIC library definitions.

Definition in file [jurassic.c](#).

### 5.13.2 Function Documentation

#### 5.13.2.1 [size\\_t atm2x \( \[ctl\\\_t\]\(#\) \\*ctl, \[atm\\\_t\]\(#\) \\*atm, \[gsl\\\_vector\]\(#\) \\*x, int \\*iqa, int \\*ipa \)](#)

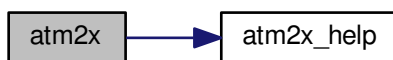
Compose state vector or parameter vector.

Definition at line 29 of file [jurassic.c](#).

```
00034     {
00035
00036     int ig, iw;
00037
00038     size_t n = 0;
00039
00040     /* Add pressure... */
00041     atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042               atm->p, IDXP, x, iqa, ipa, &n);
00043
00044     /* Add temperature... */
00045     atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046               atm->t, IDXT, x, iqa, ipa, &n);
00047
00048     /* Add volume mixing ratios... */
00049     for (ig = 0; ig < ctl->ng; ig++)
00050         atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                   atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053     /* Add extinction... */
00054     for (iw = 0; iw < ctl->nw; iw++)
00055         atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                   atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058     return n;
00059 }
```



Here is the call graph for this function:



**5.13.2.2** void atm2x\_help ( atm\_t \* atm, double zmin, double zmax, double \* value, int val\_iqa, gsl\_vector \* x, int \* iqa, int \* ipa, size\_t \* n )

Add elements to state vector.

Definition at line 63 of file [jurassic.c](#).

```

00072         {
00073
00074     int ip;
00075
00076     /* Add elements to state vector... */
00077     for (ip = 0; ip < atm->np; ip++)
00078         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079             if (x != NULL)
00080                 gsl_vector_set(x, *n, value[ip]);
00081             if (iqa != NULL)
00082                 iqa[*n] = val_iqa;
00083             if (ipa != NULL)
00084                 ipa[*n] = ip;
00085             (*n)++;
00086         }
00087 }
  
```

**5.13.2.3** double brightness ( double rad, double nu )

Compute brightness temperature.

Definition at line 91 of file [jurassic.c](#).

```

00093     {
00094
00095     return C2 * nu / gsl_log1p(C1 * POW3(nu) / rad);
00096 }
  
```

**5.13.2.4** void cart2geo ( double \* x, double \* z, double \* lon, double \* lat )

Convert Cartesian coordinates to geolocation.

Definition at line 101 of file [jurassic.c](#).

```

00105     {
00106
00107     double radius;
00108
00109     radius = NORM(x);
00110     *lat = asin(x[2] / radius) * 180 / M_PI;
00111     *lon = atan2(x[1], x[0]) * 180 / M_PI;
00112     *z = radius - RE;
00113 }
  
```

5.13.2.5 void climatology ( ctl\_t\* *ctl*, atm\_t\* *atm\_mean* )

Interpolate climatological data.

Definition at line 117 of file [jurassic.c](#).

```

00119         {
00120
00121     static double z[121] = {
00122         0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00123         20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,
00124         38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125         56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126         74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127         92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128         108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129     };
00130
00131     static double pre[121] = {
00132         1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133         357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134         104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135         29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136         10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137         3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138         1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139         0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140         0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141         0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142         0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143         0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144         0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145         0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146         0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147         0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148         9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149         4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150         2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151     };
00152
00153     static double tem[121] = {
00154         285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155         229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156         215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157         222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158         241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159         262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160         258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161         237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162         220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163         207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164         190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165         178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166         201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167         272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168     };
00169
00170     static double c2h2[121] = {
00171         1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172         2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173         5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174         2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175         9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176         1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177         1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178         1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179         2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183     };
00184
00185     static double c2h6[121] = {
00186         2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187         1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188         5.503e-10, 4.87e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189         2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190         2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191         1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192         5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193         2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194         1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195         7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,

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00196      3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197      1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198      4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199      1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200      3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00203  };
00204
00205  static double ccl4[121] = {
00206      1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207      1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208      8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209      3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210      3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
00211      4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219      1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220      1e-14, 1e-14, 1e-14
00221  };
00222
00223  static double ch4[121] = {
00224      1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225      1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226      1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227      1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228      1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229      8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230      6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231      4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232      3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233      2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234      1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235      1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236      1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237      9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238      7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239      5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240      4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241      3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242      2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243      2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244      1.782e-08
00245  };
00246
00247  static double clo[121] = {
00248      7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249      6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250      8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251      2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252      1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253      2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254      4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255      5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256      3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257      1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258      6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259      2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260      8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261      3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262      1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263      3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264      1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265      3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266      1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267      5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268      3.148e-15
00269  };
00270
00271  static double clono2[121] = {
00272      1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273      1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274      2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275      2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276      8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277      6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278      1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279      1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280      1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281      1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282      9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
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00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293 };
00294
00295 static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
00298     5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299     2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300     1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301     2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302     3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303     3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304     6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305     2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306     8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307     2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308     3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309     6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310     1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311     1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312     3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313     5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314     6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315     7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05
00316 };
00317
00318 static double cof2[121] = {
00319     7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320     6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321     7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322     4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323     1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324     1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325     1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326     8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327     5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328     2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329     7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330     1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331     4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332     1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333     2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334     4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335     7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336     1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337     3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338     1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339     4.662e-18
00340 };
00341
00342 static double f11[121] = {
00343     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345     2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346     1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347     7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348     5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349     1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350     3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351     6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352     1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353     1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354     2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355     2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356     2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357     2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358     1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359     1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360     1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361     2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362     4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363 };
00364
00365 static double f12[121] = {
00366     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368     5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369     4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
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00370      2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371      5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372      2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373      8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374      3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375      1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376      8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377      4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378      2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379      9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380      4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381      1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382      7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383      3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384      1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
00385      1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386  };
00387
00388  static double f14[121] = {
00389      9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390      9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391      8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405      7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11
00406  };
00407
00408  static double f22[121] = {
00409      1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410      1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411      1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412      7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413      4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414      3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415      1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416      1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417      8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418      5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419      4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420      3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421      3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422      2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423      2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424      2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425      1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426      1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427      1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428      1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429  };
00430
00431  static double h2o[121] = {
00432      0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433      0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434      6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435      4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436      4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437      5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438      5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439      6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440      6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441      6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442      5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443      4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444      3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445      2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446      1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447      5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448      1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449      7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450      3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451      1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452  };
00453
00454  static double h2o2[121] = {
00455      1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456      4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
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00457     3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458     1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459     8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460     1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461     1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462     6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463     5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464     4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465     3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466     2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467     1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468     1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469     9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470     7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471     4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
00472     3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473     2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474     2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475     1.775e-12
00476 };
00477
00478 static double hcn[121] = {
00479     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481     5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482     1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483     1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484     1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485     1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486     1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487     1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488     9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489     8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490     7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491     6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492     6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493     6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494     6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495     5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496     5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497     5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498     5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499 };
00500
00501 static double hno3[121] = {
00502     1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503     2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504     5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505     3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506     8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507     3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508     8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509     1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510     6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511     3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512     1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513     9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514     5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515     2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516     1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517     5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518     2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519     1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520     5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521     3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522     2.332e-14
00523 };
00524
00525 static double hno4[121] = {
00526     6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527     1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528     3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529     1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530     2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531     1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532     3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533     2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534     1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535     2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536     1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537     5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538     2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539     8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540     3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541     1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542     3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543     1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
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00544      5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545      2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546      1.64e-18
00547  };
00548
00549  static double hoc1[121] = {
00550      1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551      2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552      5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553      1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554      4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555      7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556      1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557      6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558      1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
00559      3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560      6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561      1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562      1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563      2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564      3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565      4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566      5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567      6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568      9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569      2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570      7.881e-21
00571  };
00572
00573  static double n2o[121] = {
00574      3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575      3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576      2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577      2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578      1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579      7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580      2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581      1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582      5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583      2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584      1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585      1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586      9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587      7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588      5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589      4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590      3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591      2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592      2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593      2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594  };
00595
00596  static double n2o5[121] = {
00597      1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598      1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599      4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600      7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601      3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602      2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603      2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604      6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611      1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612      1e-16, 1e-16
00613  };
00614
00615  static double nh3[121] = {
00616      1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617      1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618      4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619      5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620      6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621      1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622      1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623      1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624      2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
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00631     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635     1.914e-17
00636 };
00637
00638 static double no[121] = {
00639     2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640     1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641     7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642     1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643     8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644     5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645     1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,
00646     1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647     9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648     3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649     8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650     1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651     2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652     1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653     7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654     6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655     3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656     1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657     5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658     9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659     0.0001133
00660 };
00661
00662 static double no2[121] = {
00663     3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664     2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665     9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666     9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667     3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668     7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669     7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670     2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671     2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672     3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673     6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674     9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675     2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676     1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681 };
00682
00683 static double o3[121] = {
00684     2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685     5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686     1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687     1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688     4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689     6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690     7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691     5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692     3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693     1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694     9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695     4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696     2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697     2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698     3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699     8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700     8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701     3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702     6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703     5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704     3.665e-10
00705 };
00706
00707 static double ocs[121] = {
00708     6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709     5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710     4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711     1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712     1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713     5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714     1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
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00718     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727     1.091e-14, 1.091e-14, 1.091e-14
00728 };
00729
00730 static double sf6[121] = {
00731     4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732     4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750 };
00751
00752 static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768 };
00769
00770 static int ig_co2 = -999;
00771
00772 double co2, *q[NG] = { NULL };
00773
00774 int ig, ip, iw, iz;
00775
00776 /* Find emitter index of CO2... */
00777 if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780 /* Identify variable... */
00781 for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784         q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786         q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788         q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790         q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792         q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794         q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796         q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798         q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800         q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802         q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804         q[ig] = f14;

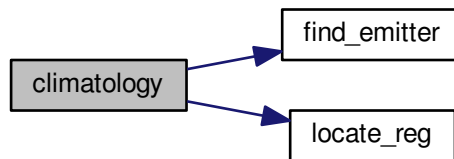
```

```

00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806         q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808         q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810         q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812         q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814         q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816         q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOCl") == 0)
00818         q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)
00820         q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822         q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824         q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826         q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828         q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830         q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832         q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834         q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836         q[ig] = so2;
00837 }
00838
00839 /* Loop over atmospheric data points... */
00840 for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853         if (q[ig] != NULL)
00854             atm->q[ig][ip] =
00855                 LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856         else
00857             atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861         co2 =
00862             371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863         atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868         atm->k[iw][ip] = 0;
00869 }
00870 }

```

Here is the call graph for this function:



#### 5.13.2.6 double ctmco2 ( double *nu*, double *p*, double *t*, double *u* )

Compute carbon dioxide continuum (optical depth).

Definition at line 874 of file [jurassic.c](#).

```

00878     {
00879
00880     static double co2296[2001] = { 9.3388e-5, 9.7711e-5, 1.0224e-4, 1.0697e-4,
00881     1.1193e-4, 1.1712e-4, 1.2255e-4, 1.2824e-4, 1.3419e-4, 1.4043e-4,
00882     1.4695e-4, 1.5378e-4, 1.6094e-4, 1.6842e-4, 1.7626e-4, 1.8447e-4,
00883     1.9307e-4, 2.0207e-4, 2.1149e-4, 2.2136e-4, 2.3169e-4, 2.4251e-4,
00884     2.5384e-4, 2.657e-4, 2.7813e-4, 2.9114e-4, 3.0477e-4, 3.1904e-4,
00885     3.3399e-4, 3.4965e-4, 3.6604e-4, 3.8322e-4, 4.0121e-4, 4.2006e-4,
00886     4.398e-4, 4.6047e-4, 4.8214e-4, 5.0483e-4, 5.286e-4, 5.535e-4,
00887     5.7959e-4, 6.0693e-4, 6.3557e-4, 6.6558e-4, 6.9702e-4, 7.2996e-4,
00888     7.6449e-4, 8.0066e-4, 8.3856e-4, 8.7829e-4, 9.1991e-4, 9.6354e-4,
00889     .0010093, .0010572, .0011074, .00116, .0012152, .001273,
00890     .0013336, .0013972, .0014638, .0015336, .0016068, .0016835,
00891     .001764, .0018483, .0019367, .0020295, .0021267, .0022286,
00892     .0023355, .0024476, .0025652, .0026885, .0028178, .0029534,
00893     .0030956, .0032448, .0034012, .0035654, .0037375, .0039181,
00894     .0041076, .0043063, .0045148, .0047336, .0049632, .005204,
00895     .0054567, .0057219, .0060002, .0062923, .0065988, .0069204,
00896     .007258, .0076123, .0079842, .0083746, .0087844, .0092146,
00897     .0096663, .01014, .010638, .011161, .01171, .012286, .012891,
00898     .013527, .014194, .014895, .015631, .016404, .017217, .01807,
00899     .018966, .019908, .020897, .021936, .023028, .024176, .025382,
00900     .026649, .027981, .02938, .030851, .032397, .034023, .035732,
00901     .037528, .039416, .041402, .04349, .045685, .047994, .050422,
00902     .052975, .055661, .058486, .061458, .064584, .067873, .071334,
00903     .074975, .078807, .082839, .087082, .091549, .096249, .1012,
00904     .10641, .11189, .11767, .12375, .13015, .13689, .14399, .15147,
00905     .15935, .16765, .17639, .18561, .19531, .20554, .21632, .22769,
00906     .23967, .25229, .2656, .27964, .29443, .31004, .3265, .34386,
00907     .36218, .3815, .40188, .42339, .44609, .47004, .49533, .52202,
00908     .5502, .57995, .61137, .64455, .6796, .71663, .75574, .79707,
00909     .84075, .88691, .9357, .98728, 1.0418, 1.0995, 1.1605, 1.225,
00910     1.2932, 1.3654, 1.4418, 1.5227, 1.6083, 1.6989, 1.7948, 1.8964,
00911     2.004, 2.118, 2.2388, 2.3668, 2.5025, 2.6463, 2.7988, 2.9606,
00912     3.1321, 3.314, 3.5071, 3.712, 3.9296, 4.1605, 4.4058, 4.6663,
00913     4.9431, 5.2374, 5.5501, 5.8818, 6.2353, 6.6114, 7.0115, 7.4372,
00914     7.8905, 8.3731, 8.8871, 9.4349, 10.019, 10.641, 11.305, 12.013,
00915     12.769, 13.576, 14.437, 15.358, 16.342, 17.39, 18.513, 19.716,
00916     21.003, 22.379, 23.854, 25.436, 27.126, 28.942, 30.89, 32.973,
00917     35.219, 37.634, 40.224, 43.021, 46.037, 49.29, 52.803, 56.447,
00918     60.418, 64.792, 69.526, 74.637, 80.182, 86.193, 92.713, 99.786,
00919     107.47, 115.84, 124.94, 134.86, 145.69, 157.49, 170.3, 184.39,
00920     199.83, 216.4, 234.55, 254.72, 276.82, 299.85, 326.16, 354.99,
00921     386.51, 416.68, 449.89, 490.12, 534.35, 578.25, 632.26, 692.61,
00922     756.43, 834.75, 924.11, 1016.9, 996.96, 1102.7, 1219.2, 1351.9,
00923     1494.3, 1654.1, 1826.5, 2027.9, 2249., 2453.8, 2714.4, 2999.4,
00924     3209.5, 3509., 3840.4, 3907.5, 4190.7, 4533.5, 4648.3, 5059.1,
00925     5561.6, 6191.4, 6820.8, 7905.9, 9362.2, 2431.3, 2211.3, 2046.8,
00926     2023.8, 1985.9, 1905.9, 1491.1, 1369.8, 1262.2, 1200.7, 887.74,
00927     820.25, 885.23, 887.21, 816.73, 1126.9, 1216.2, 1272.4, 1579.5,
00928     1634.2, 1656.3, 1657.9, 1789.5, 1670.8, 1509.5, 8474.6, 7489.2,
00929     6793.6, 6117., 5574.1, 5141.2, 5084.6, 4745.1, 4413.2, 4102.8,
  
```

```

00930 4024.7, 3715., 3398.6, 3100.8, 2900.4, 2629.2, 2374., 2144.7,
00931 1955.8, 1760.8, 1591.2, 1435.2, 1296.2, 1174., 1065.1, 967.76,
00932 999.48, 897.45, 809.23, 732.77, 670.26, 611.93, 560.11, 518.77,
00933 476.84, 438.8, 408.48, 380.21, 349.24, 322.71, 296.65, 272.85,
00934 251.96, 232.04, 213.88, 197.69, 182.41, 168.41, 155.79, 144.05,
00935 133.31, 123.48, 114.5, 106.21, 98.591, 91.612, 85.156, 79.204,
00936 73.719, 68.666, 63.975, 59.637, 56.35, 52.545, 49.042, 45.788,
00937 42.78, 39.992, 37.441, 35.037, 32.8, 30.744, 28.801, 26.986,
00938 25.297, 23.731, 22.258, 20.883, 19.603, 18.403, 17.295, 16.249,
00939 15.271, 14.356, 13.501, 12.701, 11.954, 11.254, 10.6, 9.9864,
00940 9.4118, 8.8745, 8.3714, 7.8997, 7.4578, 7.0446, 6.6573, 6.2949,
00941 5.9577, 5.6395, 5.3419, 5.063, 4.8037, 4.5608, 4.3452, 4.1364,
00942 3.9413, 3.7394, 3.562, 3.3932, 3.2325, 3.0789, 2.9318, 2.7898,
00943 2.6537, 2.5225, 2.3958, 2.2305, 2.1215, 2.0245, 1.9427, 1.8795,
00944 1.8336, 1.7604, 1.7016, 1.6419, 1.5282, 1.4611, 1.3443, 1.27,
00945 1.1675, 1.0824, 1.0534, .99833, .95854, .92981, .90887, .89346,
00946 .88113, .87068, .86102, .85096, .88262, .86151, .83565, .80518,
00947 .77045, .73736, .74744, .74954, .75773, .82267, .83493, .89402,
00948 .89725, .93426, .95564, .94045, .94174, .93404, .92035, .90456,
00949 .88621, .86673, .78117, .7515, .72056, .68822, .65658, .62764,
00950 .55984, .55598, .57407, .60963, .63763, .66198, .61132, .60972,
00951 .52496, .50649, .41872, .3964, .32422, .27276, .24048, .23772,
00952 .2286, .22711, .23999, .32038, .34371, .36621, .38561, .39953,
00953 .40636, .44913, .42716, .3919, .35477, .33935, .3351, .39746,
00954 .40993, .49398, .49956, .56157, .54742, .57295, .57386, .55417,
00955 .50745, .471, .43446, .39102, .34993, .31269, .27888, .24912,
00956 .22291, .19994, .17972, .16197, .14633, .13252, .12029, .10942,
00957 .099745, .091118, .083404, .076494, .070292, .064716, .059697,
00958 .055173, .051093, .047411, .044089, .041092, .038392, .035965,
00959 .033789, .031846, .030122, .028607, .02729, .026169, .025209,
00960 .024405, .023766, .023288, .022925, .022716, .022681, .022685,
00961 .022768, .023133, .023325, .023486, .024004, .024126, .024083,
00962 .023785, .024023, .023029, .021649, .021108, .019454, .017809,
00963 .017292, .016635, .017037, .018068, .018977, .018756, .017847,
00964 .016557, .016142, .014459, .012869, .012381, .010875, .0098701,
00965 .009285, .0091698, .0091701, .0096145, .010553, .01106, .012613,
00966 .014362, .015017, .016507, .017741, .01768, .017784, .0171,
00967 .016357, .016172, .017257, .018978, .020935, .021741, .023567,
00968 .025183, .025589, .026732, .027648, .028278, .028215, .02856,
00969 .029015, .029062, .028851, .028497, .027825, .027801, .026523,
00970 .02487, .022967, .022168, .020194, .018605, .017903, .018439,
00971 .019697, .020311, .020855, .020057, .018608, .016738, .015963,
00972 .013844, .011801, .011134, .0097573, .0086007, .0086226,
00973 .0083721, .0090978, .0097616, .0098426, .011317, .012853, .01447,
00974 .014657, .015771, .016351, .016079, .014829, .013431, .013185,
00975 .013207, .01448, .016176, .017971, .018265, .019526, .020455,
00976 .019797, .019802, .0194, .018176, .017505, .016197, .015339,
00977 .014401, .013213, .012203, .011186, .010236, .0093288, .0084854,
00978 .0076837, .0069375, .0062614, .0056628, .0051153, .0046015,
00979 .0041501, .003752, .0033996, .0030865, .0028077, .0025586,
00980 .0023355, .0021353, .0019553, .0017931, .0016466, .0015141,
00981 .0013941, .0012852, .0011862, .0010962, .0010142, 9.3935e-4,
00982 8.71e-4, 8.0851e-4, 7.5132e-4, 6.9894e-4, 6.5093e-4, 6.0689e-4,
00983 5.6647e-4, 5.2935e-4, 4.9525e-4, 4.6391e-4, 4.3509e-4, 4.086e-4,
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01613 11.676, 11.003, 10.369, 9.775, 9.2165, 8.6902, 8.1963, 7.7314,  
01614 7.2923, 6.8794, 6.4898, 6.122, 5.7764, 5.4525, 5.1484, 4.8611,  
01615 4.5918, 4.3379, 4.0982, 3.8716, 3.6567, 3.4545, 3.2634, 3.0828,  
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01617 1.8534, 1.7525, 1.6572, 1.5673, 1.4824, 1.4022, 1.3265, 1.2551,  
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01620 .49581, .46998, .44559, .42236, .40036, .37929, .35924, .34043,  
01621 .32238, .30547, .28931, .27405, .25975, .24616, .23341, .22133,  
01622 .20997, .19924, .18917, .17967, .17075, .16211, .15411, .14646,  
01623 .13912, .13201, .12509, .11857, .11261, .10698, .10186, .097039,  
01624 .092236, .087844, .083443, .07938, .075452, .071564, .067931,  
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01655 .0076269, .0063758, .006254, .0067749, .0067909, .0068231,
01656 .0072143, .0072762, .0072954, .007679, .0075107, .0073658,
01657 .0072441, .0071074, .0070378, .007176, .0072472, .0075844,
01658 .0079291, .008412, .0090165, .010688, .011535, .012375, .013166,
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01667 .20252, .20815, .21844, .22929, .24229, .25321, .26588, .2797,
01668 .29465, .31136, .32961, .36529, .38486, .41027, .43694, .4667,
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01683 615.65, 455.05, 421.09, 306.45, 289.14, 235.7, 215.52, 274.57,
01684 316.53, 357.73, 409.89, 465.06, 521.84, 579.02, 630.64, 794.46,
01685 813., 813.56, 796.25, 761.57, 727.97, 812.14, 866.75, 932.5,
01686 1132.8, 1194.8, 1362.2, 1387.2, 1482.3, 1479.7, 1517.9, 1533.1,
01687 1534.2, 1523.3, 1522.5, 1515.5, 1505.2, 1486.5, 1454., 1412.,
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01689 1255.4, 1058.9, 1020.7, 970.59, 715.24, 512.56, 468.47, 349.3,
01690 338.26, 299.22, 301.26, 332.38, 382.08, 445.49, 515.87, 590.85,
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01692 803.36, 834.46, 1073.9, 1107.1, 1123.6, 1296., 1393.7, 1303.1,
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01696 97.877, 89.47, 81.882, 75.021, 68.807, 63.171, 58.052, 53.396,
01697 49.155, 45.288, 41.759, 38.531, 35.576, 32.868, 30.384, 28.102,
01698 26.003, 24.071, 22.293, 20.655, 19.147, 17.756, 16.476, 15.292,
01699 14.198, 13.183, 12.241, 11.367, 10.554, 9.7989, 9.0978, 8.4475,
01700 7.845, 7.2868, 6.7704, 6.2927, 5.8508, 5.4421, 5.064, 4.714,
01701 4.3902, 4.0902, 3.8121, 3.5543, 3.315, 3.093, 2.8869, 2.6953,
01702 2.5172, 2.3517, 2.1977, 2.0544, 1.9211, 1.7969, 1.6812, 1.5735,
01703 1.4731, 1.3794, 1.2921, 1.2107, 1.1346, 1.0637, .99744, .93554,
01704 .87771, .82368, .77313, .72587, .6816, .64014, .60134, .565,
01705 .53086, .49883, .46881, .44074, .4144, .38979, .36679, .34513,
01706 .32474, .30552, .28751, .27045, .25458, .23976, .22584, .21278,
01707 .20051, .18899, .17815, .16801, .15846, .14954, .14117, .13328,
01708 .12584
01709 };
01710
01711 double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmph;
01712
```

```

01713     int iw;
01714
01715     /* Get CO2 continuum absorption... */
01716     xw = nu / 2 + 1;
01717     if (xw >= 1 && xw < 2001) {
01718         iw = (int) xw;
01719         dw = xw - iw;
01720         ew = 1 - dw;
01721         cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722         cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723         cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724         dt230 = t - 230;
01725         dt260 = t - 260;
01726         dt296 = t - 296;
01727         ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728             * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729         ctmph = u / NA / 1000 * p / P0 * ctw;
01730     } else
01731         ctmph = 0;
01732     return ctmph;
01733 }

```

### 5.13.2.7 double ctmh2o ( double nu, double p, double t, double q, double u )

Compute water vapor continuum (optical depth).

Definition at line 1737 of file [jurassic.c](#).

```

01742     {
01743
01744     static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745     .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746     .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747     .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748     .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749     .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750     .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
01751     6.4e-4, 5.687e-4, 5.063e-4, 4.511e-4, 4.029e-4, 3.596e-4,
01752     3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753     1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754     1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
01755     6.433e-5, 6.013e-5, 5.631e-5, 5.283e-5, 4.963e-5, 4.669e-5,
01756     4.398e-5, 4.148e-5, 3.917e-5, 3.702e-5, 3.502e-5, 3.316e-5,
01757     3.142e-5, 2.978e-5, 2.825e-5, 2.681e-5, 2.546e-5, 2.419e-5,
01758     2.299e-5, 2.186e-5, 2.079e-5, 1.979e-5, 1.884e-5, 1.795e-5,
01759     1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
01760     1.312e-5, 1.263e-5, 1.218e-5, 1.178e-5, 1.143e-5, 1.112e-5,
01761     1.088e-5, 1.07e-5, 1.057e-5, 1.05e-5, 1.051e-5, 1.059e-5,
01762     1.076e-5, 1.1e-5, 1.133e-5, 1.18e-5, 1.237e-5, 1.308e-5,
01763     1.393e-5, 1.483e-5, 1.614e-5, 1.758e-5, 1.93e-5, 2.123e-5,
01764     2.346e-5, 2.647e-5, 2.93e-5, 3.279e-5, 3.745e-5, 4.152e-5,
01765     4.813e-5, 5.477e-5, 6.203e-5, 7.331e-5, 8.056e-5, 9.882e-5,
01766     1.05e-4, 1.21e-4, 1.341e-4, 1.572e-4, 1.698e-4, 1.968e-4,
01767     2.175e-4, 2.431e-4, 2.735e-4, 2.867e-4, 3.19e-4, 3.371e-4,
01768     3.554e-4, 3.726e-4, 3.837e-4, 3.878e-4, 3.864e-4, 3.858e-4,
01769     3.841e-4, 3.852e-4, 3.815e-4, 3.762e-4, 3.618e-4, 3.579e-4,
01770     3.45e-4, 3.202e-4, 3.018e-4, 2.785e-4, 2.602e-4, 2.416e-4,
01771     2.097e-4, 1.939e-4, 1.689e-4, 1.498e-4, 1.308e-4, 1.17e-4,
01772     1.011e-4, 9.237e-5, 7.909e-5, 7.006e-5, 6.112e-5, 5.401e-5,
01773     4.914e-5, 4.266e-5, 3.963e-5, 3.316e-5, 3.037e-5, 2.598e-5,
01774     2.294e-5, 2.066e-5, 1.813e-5, 1.583e-5, 1.423e-5, 1.247e-5,
01775     1.116e-5, 9.76e-6, 8.596e-6, 7.72e-6, 6.825e-6, 6.108e-6,
01776     5.366e-6, 4.733e-6, 4.229e-6, 3.731e-6, 3.346e-6, 2.972e-6,
01777     2.628e-6, 2.356e-6, 2.102e-6, 1.878e-6, 1.678e-6, 1.507e-6,
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01779     7.261e-7, 6.599e-7, 6.005e-7, 5.479e-7, 5.011e-7, 4.595e-7,
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01782     1.788e-7, 1.683e-7, 1.587e-7, 1.497e-7, 1.415e-7, 1.338e-7,
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01786     6.07e-8, 5.992e-8, 5.913e-8, 5.841e-8, 5.796e-8, 5.757e-8,
01787     5.746e-8, 5.731e-8, 5.679e-8, 5.577e-8, 5.671e-8, 5.656e-8,
01788     5.594e-8, 5.593e-8, 5.602e-8, 5.62e-8, 5.693e-8, 5.725e-8,
01789     5.858e-8, 6.037e-8, 6.249e-8, 6.535e-8, 6.899e-8, 7.356e-8,
01790     7.918e-8, 8.618e-8, 9.385e-8, 1.039e-7, 1.158e-7, 1.29e-7,
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02687    1.602e-13, 2.239e-13, 3.075e-13, 4.134e-13, 5.749e-13, 7.886e-13,
02688    1.071e-12, 1.464e-12, 2.032e-12, 2.8e-12, 3.732e-12, 4.996e-12,
02689    6.483e-12, 8.143e-12, 1.006e-11, 1.238e-11, 1.484e-11, 1.744e-11,
02690    2.02e-11, 2.274e-11, 2.562e-11, 2.848e-11, 3.191e-11, 3.617e-11,
02691    4.081e-11, 4.577e-11, 4.937e-11, 5.204e-11, 5.401e-11, 5.462e-11,
02692    5.507e-11, 5.51e-11, 5.605e-11, 5.686e-11, 5.739e-11, 5.766e-11,
02693    5.74e-11, 5.754e-11, 5.761e-11, 5.777e-11, 5.712e-11, 5.51e-11,
02694    5.088e-11, 4.438e-11, 3.728e-11, 2.994e-11, 2.305e-11, 1.715e-11,
02695    1.256e-11, 9.208e-12, 6.745e-12, 5.014e-12, 3.785e-12, 2.9e-12,
02696    2.239e-12, 1.757e-12, 1.414e-12, 1.142e-12, 9.482e-13, 8.01e-13,
02697    6.961e-13, 6.253e-13, 5.735e-13, 5.433e-13, 5.352e-13, 5.493e-13,
02698    5.706e-13, 6.068e-13, 6.531e-13, 7.109e-13, 7.767e-13, 8.59e-13,
02699    9.792e-13, 1.142e-12, 1.371e-12, 1.65e-12, 1.957e-12, 2.302e-12,
02700    2.705e-12, 3.145e-12, 3.608e-12, 4.071e-12, 4.602e-12, 5.133e-12,
02701    5.572e-12, 5.987e-12, 6.248e-12, 6.533e-12, 6.757e-12, 6.935e-12,
02702    7.224e-12, 7.422e-12, 7.538e-12, 7.547e-12, 7.495e-12, 7.543e-12,
02703    7.725e-12, 8.139e-12, 8.627e-12, 9.146e-12, 9.443e-12, 9.318e-12,
02704    8.649e-12, 7.512e-12, 6.261e-12, 4.915e-12, 3.647e-12, 2.597e-12,
02705    1.785e-12, 1.242e-12, 8.66e-13, 6.207e-13, 4.61e-13, 3.444e-13,
02706    2.634e-13, 2.1e-13, 1.725e-13, 1.455e-13, 1.237e-13, 1.085e-13,
02707    9.513e-14, 7.978e-14, 6.603e-14, 5.288e-14, 4.084e-14, 2.952e-14,
02708    2.157e-14, 1.593e-14, 1.199e-14, 9.267e-15, 7.365e-15, 6.004e-15,
02709    4.995e-15, 4.218e-15, 3.601e-15, 3.101e-15, 2.692e-15, 2.36e-15,
02710    2.094e-15, 1.891e-15, 1.755e-15, 1.699e-15, 1.755e-15, 1.987e-15,
02711    2.506e-15, 3.506e-15, 5.289e-15, 8.311e-15, 1.325e-14, 2.129e-14,
02712    3.237e-14, 4.595e-14, 6.441e-14, 8.433e-14, 1.074e-13, 1.383e-13,
02713    1.762e-13, 2.281e-13, 2.831e-13, 3.523e-13, 4.38e-13, 5.304e-13,
02714    6.29e-13, 7.142e-13, 8.032e-13, 8.934e-13, 9.888e-13, 1.109e-12,
02715    1.261e-12, 1.462e-12, 1.74e-12, 2.099e-12, 2.535e-12, 3.008e-12,
02716    3.462e-12, 3.856e-12, 4.098e-12, 4.239e-12, 4.234e-12, 4.132e-12,
02717    3.986e-12, 3.866e-12, 3.829e-12, 3.742e-12, 3.705e-12, 3.694e-12,
02718    3.765e-12, 3.849e-12, 3.929e-12, 4.056e-12, 4.092e-12, 4.047e-12,
02719    3.792e-12, 3.407e-12, 2.953e-12, 2.429e-12, 1.931e-12, 1.46e-12,
02720    1.099e-12, 8.199e-13, 6.077e-13, 4.449e-13, 3.359e-13, 2.524e-13,
02721    1.881e-13, 1.391e-13, 1.02e-13, 7.544e-14, 5.555e-14, 4.22e-14,
02722    3.321e-14, 2.686e-14, 2.212e-14, 1.78e-14, 1.369e-14, 1.094e-14,
02723    9.13e-15, 8.101e-15, 7.828e-15, 8.393e-15, 1.012e-14, 1.259e-14,
02724    1.538e-14, 1.961e-14, 2.619e-14, 3.679e-14, 5.049e-14, 6.917e-14,
02725    8.88e-14, 1.115e-13, 1.373e-13, 1.619e-13, 1.878e-13, 2.111e-13,
02726    2.33e-13, 2.503e-13, 2.613e-13, 2.743e-13, 2.826e-13, 2.976e-13,
02727    3.162e-13, 3.36e-13, 3.491e-13, 3.541e-13, 3.595e-13, 3.608e-13,
02728    3.709e-13, 3.869e-13, 4.12e-13, 4.366e-13, 4.504e-13, 4.379e-13,
02729    3.955e-13, 3.385e-13, 2.741e-13, 2.089e-13, 1.427e-13, 9.294e-14,
02730    5.775e-14, 3.565e-14, 2.21e-14, 1.398e-14, 9.194e-15, 6.363e-15,
02731    4.644e-15, 3.55e-15, 2.808e-15, 2.274e-15, 1.871e-15, 1.557e-15,
02732    1.308e-15, 1.108e-15, 9.488e-16, 8.222e-16, 7.238e-16, 6.506e-16,
02733    6.008e-16, 5.742e-16, 5.724e-16, 5.991e-16, 6.625e-16, 7.775e-16,
02734    9.734e-16, 1.306e-15, 1.88e-15, 2.879e-15, 4.616e-15, 7.579e-15,
02735    1.248e-14, 2.03e-14, 3.244e-14, 5.171e-14, 7.394e-14, 9.676e-14,
02736    1.199e-13, 1.467e-13, 1.737e-13, 2.02e-13, 2.425e-13, 3.016e-13,
02737    3.7e-13, 4.617e-13, 5.949e-13, 7.473e-13, 9.378e-13, 1.191e-12,
02738    1.481e-12, 1.813e-12, 2.232e-12, 2.722e-12, 3.254e-12, 3.845e-12,
02739    4.458e-12, 5.048e-12, 5.511e-12, 5.898e-12, 6.204e-12, 6.293e-12,
02740    6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741    6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742    7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743    2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744    4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745    };
02746
02747    static double xfcrev[15] =
02748    { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749      1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750    };
```



```

02751
02752 double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753 sfac, fscal, cwfrn, ctmph, ctwfrn, ctwsf;
02754
02755 int iw, ix;
02756
02757 /* Get H2O continuum absorption... */
02758 xw = nu / 10 + 1;
02759 if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767         sfac = 1;
02768     } else {
02769         xx = (nu - 820) / 10;
02770         ix = (int) xx;
02771         dx = xx - ix;
02772         sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctwsf = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctwsf + (1 - q) * ctwfrn) * 1e-20;
02782     ctmph = a1 * a2 * a3;
02783 } else
02784     ctmph = 0;
02785 return ctmph;
02786 }

```

### 5.13.2.8 double ctmn2 ( double nu, double p, double t )

Compute nitrogen continuum (absorption coefficient).

Definition at line 2790 of file [jurassic.c](#).

```

02793 {
02794
02795 static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796 1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797 2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798 5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799 7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800 9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801 1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802 1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803 1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804 1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805 7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806 3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807 1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808 7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809 };
02810
02811 static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812 511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813 233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814 -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815 -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816 -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817 -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818 121., 141., 152., 161., 164., 164., 155., 148., 143., 137.,
02819 133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820 372., 449., 514., 569., 609., 642., 673., 673.
02821 };
02822
02823 static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824 2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825 2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826 2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827 2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828 2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829 2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,

```

```

02830     2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831     2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832     2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833     2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834 };
02835
02836 double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838 int idx;
02839
02840 /* Check wavenumber range... */
02841 if (nu < nua[0] || nu > nua[97])
02842     return 0;
02843
02844 /* Interpolate B and beta... */
02845 idx = locate_reg(nua, 98, nu);
02846 b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847 beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849 /* Compute absorption coefficient... */
02850 return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851     * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }

```

Here is the call graph for this function:



#### 5.13.2.9 double ctmo2 ( double nu, double p, double t )

Compute oxygen continuum (absorption coefficient).

Definition at line 2856 of file [jurassic.c](#).

```

02859     {
02860
02861     static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862     .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863     1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864     2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865     4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866     3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867     2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868     1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869     .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870     .071, .064, 0.
02871     };
02872
02873     static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874     531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875     193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876     -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877     -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878     -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879     123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880     321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881     346., 322., 291., 290., 350., 371., 504., 504.
02882     };
02883
02884     static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885     1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886     1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887     1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888     1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,

```

```

02889      1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890      1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891      1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892      1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893      1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894      1800., 1805.
02895  };
02896
02897  double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899  int idx;
02900
02901  /* Check wavenumber range... */
02902  if (nu < nua[0] || nu > nua[89])
02903      return 0;
02904
02905  /* Interpolate B and beta... */
02906  idx = locate_reg(nua, 90, nu);
02907  b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02908  beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910  /* Compute absorption coefficient... */
02911  return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912      b;
02913 }

```

Here is the call graph for this function:



#### 5.13.2.10 void copy\_atm ( ctl\_t \*ctl, atm\_t \*atm\_dest, atm\_t \*atm\_src, int init )

Copy and initialize atmospheric data.

Definition at line 2917 of file [jurassic.c](#).

```

02921      {
02922
02923      int ig, ip, iw;
02924
02925      size_t s;
02926
02927      /* Data size... */
02928      s = (size_t) atm_src->np * sizeof(double);
02929
02930      /* Copy data... */
02931      atm_dest->np = atm_src->np;
02932      memcpy(atm_dest->time, atm_src->time, s);
02933      memcpy(atm_dest->z, atm_src->z, s);
02934      memcpy(atm_dest->lon, atm_src->lon, s);
02935      memcpy(atm_dest->lat, atm_src->lat, s);
02936      memcpy(atm_dest->p, atm_src->p, s);
02937      memcpy(atm_dest->t, atm_src->t, s);
02938      for (ig = 0; ig < ctl->ng; ig++)
02939          memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940      for (iw = 0; iw < ctl->nw; iw++)
02941          memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943      /* Initialize... */
02944      if (init)
02945          for (ip = 0; ip < atm_dest->np; ip++) {
02946              atm_dest->p[ip] = 0;
02947              atm_dest->t[ip] = 0;
02948              for (ig = 0; ig < ctl->ng; ig++)
02949                  atm_dest->q[ig][ip] = 0;
02950              for (iw = 0; iw < ctl->nw; iw++)
02951                  atm_dest->k[iw][ip] = 0;
02952          }
02953 }

```

**5.13.2.11 void copy\_obs ( ctl\_t \* *ctl*, obs\_t \* *obs\_dest*, obs\_t \* *obs\_src*, int *init* )**

Copy and initialize observation data.

Definition at line 2957 of file [jurassic.c](#).

```

02961         {
02962
02963     int id, ir;
02964
02965     size_t s;
02966
02967     /* Data size... */
02968     s = (size_t) obs_src->nr * sizeof(double);
02969
02970     /* Copy data... */
02971     obs_dest->nr = obs_src->nr;
02972     memcpy(obs_dest->time, obs_src->time, s);
02973     memcpy(obs_dest->obsz, obs_src->obsz, s);
02974     memcpy(obs_dest->obslon, obs_src->obslon, s);
02975     memcpy(obs_dest->obslat, obs_src->obslat, s);
02976     memcpy(obs_dest->vpz, obs_src->vpz, s);
02977     memcpy(obs_dest->vplon, obs_src->vplon, s);
02978     memcpy(obs_dest->vplat, obs_src->vplat, s);
02979     memcpy(obs_dest->tpz, obs_src->tpz, s);
02980     memcpy(obs_dest->tplon, obs_src->tplon, s);
02981     memcpy(obs_dest->tplat, obs_src->tplat, s);
02982     for (id = 0; id < ctl->nd; id++)
02983         memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984     for (id = 0; id < ctl->nd; id++)
02985         memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987     /* Initialize... */
02988     if (init)
02989         for (id = 0; id < ctl->nd; id++)
02990             for (ir = 0; ir < obs_dest->nr; ir++)
02991                 if (gsl_finite(obs_dest->rad[id][ir])) {
02992                     obs_dest->rad[id][ir] = 0;
02993                     obs_dest->tau[id][ir] = 0;
02994                 }
02995 }
```

**5.13.2.12 int find\_emitter ( ctl\_t \* *ctl*, const char \* *emitter* )**

Find index of an emitter.

Definition at line 2999 of file [jurassic.c](#).

```

03001         {
03002
03003     int ig;
03004
03005     for (ig = 0; ig < ctl->ng; ig++)
03006         if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007             return ig;
03008
03009     return -1;
03010 }
```

**5.13.2.13 void formod ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs* )**

Determine ray paths and compute radiative transfer.

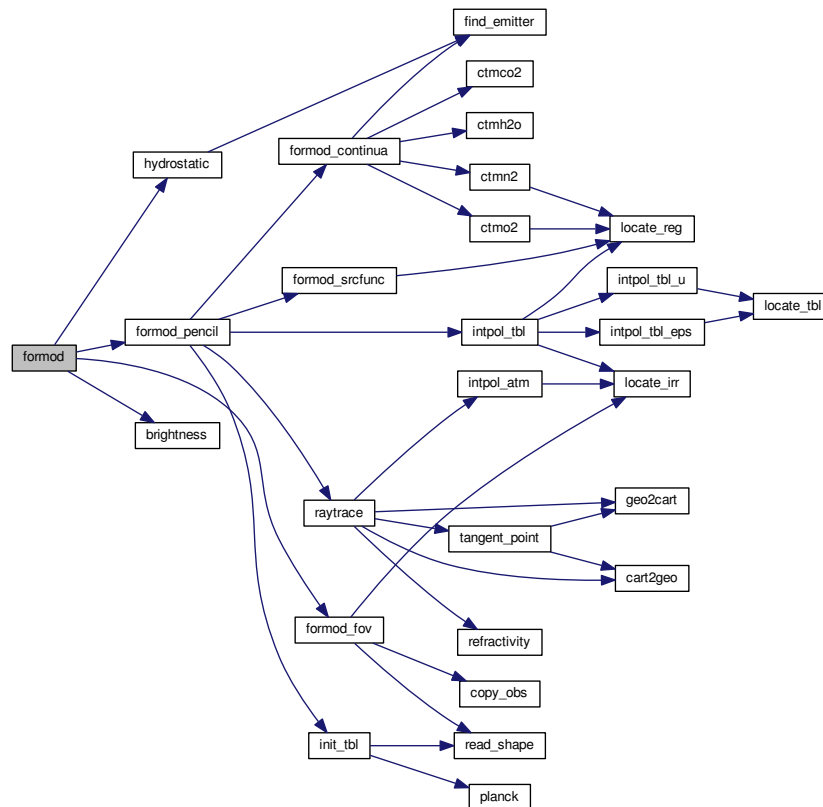
Definition at line 3014 of file [jurassic.c](#).

```

03017         {
03018
03019     int id, ir, *mask;
03020
03021     /* Allocate... */
03022     ALLOC(mask, int,
03023           ND * NR);
03024
03025     /* Save observation mask... */
03026     for (id = 0; id < ctl->nd; id++)
03027         for (ir = 0; ir < obs->nr; ir++)
03028             mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030     /* Hydrostatic equilibrium... */
03031     hydrostatic(ctl, atm);
03032
03033     /* Calculate pencil beams... */
03034     for (ir = 0; ir < obs->nr; ir++)
03035         formod_pencil(ctl, atm, obs, ir);
03036
03037     /* Apply field-of-view convolution... */
03038     formod_fov(ctl, obs);
03039
03040     /* Convert radiance to brightness temperature... */
03041     if (ctl->write_bbt)
03042         for (id = 0; id < ctl->nd; id++)
03043             for (ir = 0; ir < obs->nr; ir++)
03044                 obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046     /* Apply observation mask... */
03047     for (id = 0; id < ctl->nd; id++)
03048         for (ir = 0; ir < obs->nr; ir++)
03049             if (mask[id * NR + ir])
03050                 obs->rad[id][ir] = GSL_NAN;
03051
03052     /* Free... */
03053     free(mask);
03054 }

```

Here is the call graph for this function:



#### 5.13.2.14 void formod\_continua ( ctl\_t \* *ctl*, los\_t \* *los*, int *ip*, double \* *beta* )

Compute absorption coefficient of continua.

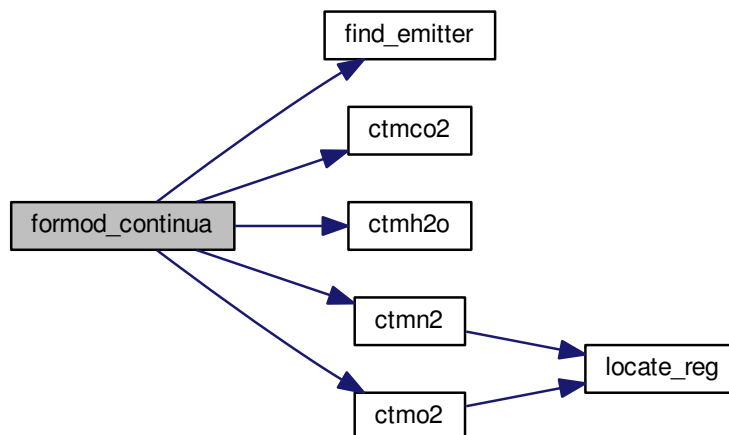
Definition at line 3058 of file [jurassic.c](#).

```

03062         {
03063
03064     static int ig_co2 = -999, ig_h2o = -999;
03065
03066     int id;
03067
03068     /* Extinction... */
03069     for (id = 0; id < ctl->nd; id++)
03070         beta[id] = los->k[ctl->window[id]][ip];
03071
03072     /* CO2 continuum... */
03073     if (ctl->ctm_co2) {
03074         if (ig_co2 == -999)
03075             ig_co2 = find_emitter(ctl, "CO2");
03076         if (ig_co2 >= 0)
03077             for (id = 0; id < ctl->nd; id++)
03078                 beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                                     los->u[ig_co2][ip]) / los->ds[ip];
03080     }
03081
03082     /* H2O continuum... */
03083     if (ctl->ctm_h2o) {
03084         if (ig_h2o == -999)
03085             ig_h2o = find_emitter(ctl, "H2O");
03086         if (ig_h2o >= 0)
03087             for (id = 0; id < ctl->nd; id++)
03088                 beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                                     los->q[ig_h2o][ip],
03090                                     los->u[ig_h2o][ip]) / los->ds[ip];
03091     }
03092
03093     /* N2 continuum... */
03094     if (ctl->ctm_n2)
03095         for (id = 0; id < ctl->nd; id++)
03096             beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098     /* O2 continuum... */
03099     if (ctl->ctm_o2)
03100         for (id = 0; id < ctl->nd; id++)
03101             beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }

```

Here is the call graph for this function:



### 5.13.2.15 void formod\_fov ( ctl\_t \*ctl, obs\_t \*obs )

Apply field of view convolution.

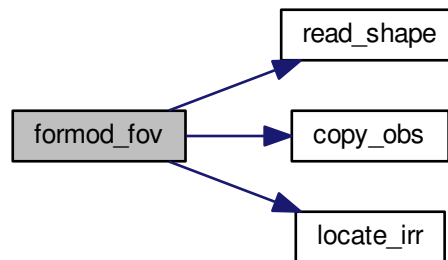
Definition at line 3106 of file [jurassic.c](#).

```

03108         {
03109
03110     static double dz[NSHAPE], w[NSHAPE];
03111
03112     static int init = 0, n;
03113
03114     obs_t *obs2;
03115
03116     double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03117
03118     int i, id, idx, ir, ir2, nz;
03119
03120     /* Do not take into account FOV... */
03121     if (ctl->fov[0] == '-')
03122         return;
03123
03124     /* Initialize FOV data... */
03125     if (!init) {
03126         init = 1;
03127         read_shape(ctl->fov, dz, w, &n);
03128     }
03129
03130     /* Allocate... */
03131     ALLOC(obs2, obs_t, 1);
03132
03133     /* Copy observation data... */
03134     copy_obs(ctl, obs2, obs, 0);
03135
03136     /* Loop over ray paths... */
03137     for (ir = 0; ir < obs->nr; ir++) {
03138
03139         /* Get radiance and transmittance profiles... */
03140         nz = 0;
03141         for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03142             ir2++)
03143             if (obs->time[ir2] == obs->time[ir]) {
03144                 z[nz] = obs2->vpz[ir2];
03145                 for (id = 0; id < ctl->nd; id++) {
03146                     rad[id][nz] = obs2->rad[id][ir2];
03147                     tau[id][nz] = obs2->tau[id][ir2];
03148                 }
03149                 nz++;
03150             }
03151         if (nz < 2)
03152             ERRMSG("Cannot apply FOV convolution!");
03153
03154         /* Convolute profiles with FOV... */
03155         wsum = 0;
03156         for (id = 0; id < ctl->nd; id++) {
03157             obs->rad[id][ir] = 0;
03158             obs->tau[id][ir] = 0;
03159         }
03160         for (i = 0; i < n; i++) {
03161             zfov = obs->vpz[ir] + dz[i];
03162             idx = locate_irr(z, nz, zfov);
03163             for (id = 0; id < ctl->nd; id++) {
03164                 obs->rad[id][ir] += w[i]
03165                     * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03166                 obs->tau[id][ir] += w[i]
03167                     * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03168             }
03169             wsum += w[i];
03170         }
03171         for (id = 0; id < ctl->nd; id++) {
03172             obs->rad[id][ir] /= wsum;
03173             obs->tau[id][ir] /= wsum;
03174         }
03175     }
03176
03177     /* Free... */
03178     free(obs2);
03179 }

```

Here is the call graph for this function:



#### 5.13.2.16 void formod\_pencil ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, int *ir* )

Compute radiative transfer for a pencil beam.

Definition at line 3183 of file [jurassic.c](#).

```

03187     {
03188
03189     static tbl_t *tbl;
03190
03191     static int init = 0;
03192
03193     los_t *los;
03194
03195     double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197     int id, ip;
03198
03199     /* Initialize look-up tables... */
03200     if (!init) {
03201         init = 1;
03202         ALLOC(tbl, tbl_t, 1);
03203         init_tbl(ctl, tbl);
03204     }
03205
03206     /* Allocate... */
03207     ALLOC(los, los_t, 1);
03208
03209     /* Initialize... */
03210     for (id = 0; id < ctl->nd; id++) {
03211         obs->rad[id][ir] = 0;
03212         obs->tau[id][ir] = 1;
03213     }
03214
03215     /* Raytracing... */
03216     raytrace(ctl, atm, obs, los, ir);
03217
03218     /* Loop over LOS points... */
03219     for (ip = 0; ip < los->np; ip++) {
03220
03221         /* Get trace gas transmittance... */
03222         intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224         /* Get continuum absorption... */
03225         formod_continua(ctl, los, ip, beta_ctm);
03226
03227         /* Compute Planck function... */
03228         formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230         /* Loop over channels... */
03231         for (id = 0; id < ctl->nd; id++)
03232             if (tau_gas[id] > 0) {
03233

```

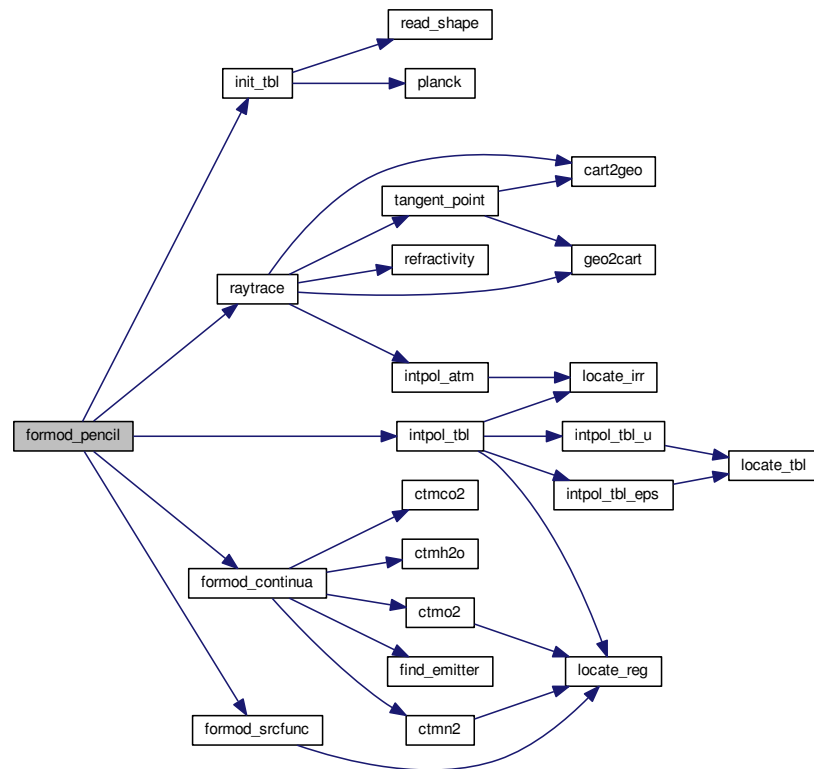


```

03234      /* Get segment emissivity... */
03235      eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237      /* Compute radiance... */
03238      obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240      /* Compute path transmittance... */
03241      obs->tau[id][ir] *= (1 - eps);
03242  }
03243  }
03244
03245  /* Add surface... */
03246  if (los->tsurf > 0) {
03247      formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248      for (id = 0; id < ctl->nd; id++)
03249          obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250  }
03251
03252  /* Free... */
03253  free(los);
03254  }

```

Here is the call graph for this function:



5.13.2.17 void formod\_srcfunc ( ctl\_t \* *ctl*, tbl\_t \* *tbl*, double *t*, double \* *src* )

Compute Planck source function.

Definition at line 3258 of file [jurassic.c](#).

```

03262      {
03263
03264      int id, it;

```

```

03265
03266  /* Determine index in temperature array... */
03267  it = locate_reg(tbl->st, TBLNS, t);
03268
03269  /* Interpolate Planck function value... */
03270  for (id = 0; id < ctl->nd; id++)
03271      src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                  tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }

```

Here is the call graph for this function:



#### 5.13.2.18 void geo2cart ( double z, double lon, double lat, double \* x )

Convert geolocation to Cartesian coordinates.

Definition at line 3277 of file [jurassic.c](#).

```

03281      {
03282
03283      double radius;
03284
03285      radius = z + RE;
03286      x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287      x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288      x[2] = radius * sin(lat / 180 * M_PI);
03289 }

```

#### 5.13.2.19 void hydrostatic ( ctl\_t \* ctl, atm\_t \* atm )

Set hydrostatic equilibrium.

Definition at line 3293 of file [jurassic.c](#).

```

03295      {
03296
03297      static int ig_h2o = -999;
03298
03299      double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301      int i, ip, ipref = 0, ipt = 20;
03302
03303      /* Check reference height... */
03304      if (ctl->hydz < 0)
03305          return;
03306
03307      /* Determine emitter index of H2O... */
03308      if (ig_h2o == -999)
03309          ig_h2o = find_emitter(ctl, "H2O");
03310
03311      /* Find air parcel next to reference height... */
03312      for (ip = 0; ip < atm->np; ip++)
03313          if (fabs(atm->z[ip] - ctl->hydz) < dzmin) {
03314              dzmin = fabs(atm->z[ip] - ctl->hydz);
03315              ipref = ip;
03316          }

```

```

03317
03318 /* Upper part of profile... */
03319 for (ip = ipref + 1; ip < atm->np; ip++) {
03320     mean = 0;
03321     for (i = 0; i < ipt; i++) {
03322         if (ig_h2o >= 0)
03323             e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                     ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03325         mean += (e * mmh2o + (1 - e) * mmair)
03326             * G0 / RI
03327             / LIN(0.0, atm->t[ip - 1], ipt - 1.0, atm->t[ip], (double) i) / ipt;
03328     }
03329
03330 /* Compute p(z,T)... */
03331 atm->p[ip] =
03332     exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333 }
03334
03335 /* Lower part of profile... */
03336 for (ip = ipref - 1; ip >= 0; ip--) {
03337     mean = 0;
03338     for (i = 0; i < ipt; i++) {
03339         if (ig_h2o >= 0)
03340             e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                     ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03342         mean += (e * mmh2o + (1 - e) * mmair)
03343             * G0 / RI
03344             / LIN(0.0, atm->t[ip + 1], ipt - 1.0, atm->t[ip], (double) i) / ipt;
03345     }
03346
03347 /* Compute p(z,T)... */
03348 atm->p[ip] =
03349     exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350 }
03351 }

```

Here is the call graph for this function:



#### 5.13.2.20 void idx2name( ctl\_t \*ctl, int idx, char \*quantity )

Determine name of state vector quantity for given index.

Definition at line 3355 of file [jurassic.c](#).

```

03358     {
03359
03360     int ig, iw;
03361
03362     if (idx == IDXP)
03363         sprintf(quantity, "PRESSURE");
03364
03365     if (idx == IDXT)
03366         sprintf(quantity, "TEMPERATURE");
03367
03368     for (ig = 0; ig < ctl->ng; ig++)
03369         if (idx == IDXQ(ig))
03370             sprintf(quantity, "%s", ctl->emitter[ig]);
03371
03372     for (iw = 0; iw < ctl->nw; iw++)
03373         if (idx == IDXK(iw))
03374             sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03375 }

```

## 5.13.2.21 void init\_tbl ( ctl\_t \* ctl, tbl\_t \* tbl )

Initialize look-up tables.

Definition at line 3379 of file [jurassic.c](#).

```

03381         {
03382
03383     FILE *in;
03384
03385     char filename[2 * LEN], line[LEN];
03386
03387     double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388            f[NSHAPE], fsum, nu[NSHAPE];
03389
03390     int i, id, ig, ip, it, n;
03391
03392     /* Loop over trace gases and channels... */
03393     for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
03395                                press_old,temp,temp_old,u,u_old,id,ip,it)
03396     for (id = 0; id < ctl->nd; id++) {
03397
03398         /* Initialize... */
03399         tbl->np[ig][id] = -1;
03400         eps_old = -999;
03401         press_old = -999;
03402         temp_old = -999;
03403         u_old = -999;
03404
03405         /* Try to open file... */
03406         sprintf(filename, "%s%.4f%s.tab",
03407                ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03408         if (!(in = fopen(filename, "r"))) {
03409             printf("Missing emissivity table: %s\n", filename);
03410             continue;
03411         }
03412         printf("Read emissivity table: %s\n", filename);
03413
03414         /* Read data... */
03415         while (fgets(line, LEN, in)) {
03416
03417             /* Parse line... */
03418             if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03419                 continue;
03420
03421             /* Determine pressure index... */
03422             if (press != press_old) {
03423                 press_old = press;
03424                 if ((++tbl->np[ig][id]) >= TBLNP)
03425                     ERRMSG("Too many pressure levels!");
03426                 tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03427             }
03428
03429             /* Determine temperature index... */
03430             if (temp != temp_old) {
03431                 temp_old = temp;
03432                 if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03433                     ERRMSG("Too many temperatures!");
03434                 tbl->nu[ig][id][tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03435             }
03436
03437             /* Determine column density index... */
03438             if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03439                [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03440                 eps_old = eps;
03441                 u_old = u;
03442                 if ((++tbl->nu[ig][id][tbl->nt[ig][id][tbl->np[ig][id]]]
03443                    [tbl->np[ig][id][tbl->nt[ig][id][tbl->np[ig][id]]]]) >= TBLNU) {
03444                     tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03445                     continue;
03446                 }
03447             }
03448
03449             /* Store data... */
03450             tbl->p[ig][id][tbl->np[ig][id]] = press;
03451             tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03452                 = temp;
03453             tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03454                 [tbl->nu[ig][id][tbl->np[ig][id]]]
03455                 [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) u;

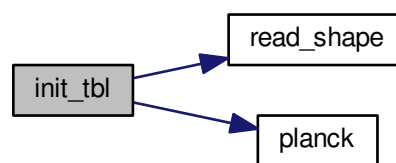
```

```

03457         tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458         [tbl->nu[ig][id][tbl->np[ig][id]]]
03459         [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) eps;
03460     }
03461
03462     /* Increment counters... */
03463     tbl->np[ig][id]++;
03464     for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465         tbl->nt[ig][id][ip]++;
03466         for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467             tbl->nu[ig][id][ip][it]++;
03468     }
03469
03470     /* Close file... */
03471     fclose(in);
03472 }
03473
03474 /* Write info... */
03475 printf("Initialize source function table...\n");
03476
03477 /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479 for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488         /* Set temperature... */
03489         tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491         /* Integrate Planck function... */
03492         fsum = 0;
03493         tbl->sr[id][it] = 0;
03494         for (i = 0; i < n; i++) {
03495             fsum += f[i];
03496             tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497         }
03498         tbl->sr[id][it] /= fsum;
03499     }
03500 }
03501 }

```

Here is the call graph for this function:



**5.13.2.22** void `intpol_atm ( ctl_t * ctl, atm_t * atm, double z, double * p, double * t, double * q, double * k )`

Interpolate atmospheric data.

Definition at line 3505 of file [jurassic.c](#).

```

03512     {
03513
03514     int ig, ip, iw;
03515

```

```

03516  /* Get array index... */
03517  ip = locate_irr(atm->z, atm->np, z);
03518
03519  /* Interpolate... */
03520  *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521  *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522  for (ig = 0; ig < ctl->ng; ig++)
03523      q[ig] =
03524          LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525  for (iw = 0; iw < ctl->nw; iw++)
03526      k[iw] =
03527          LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528  }

```

Here is the call graph for this function:



**5.13.2.23** void intpol\_tbl ( ctl\_t \* *ctl*, tbl\_t \* *tbl*, los\_t \* *los*, int *ip*, double *tau\_path*[NG][ND], double *tau\_seg*[ND] )

Get transmittance from look-up tables.

Definition at line 3532 of file [jurassic.c](#).

```

03538      {
03539
03540      double eps, eps00, eps01, eps10, eps11, u;
03541
03542      int id, ig, ipr, it0, it1;
03543
03544      /* Initialize... */
03545      if (ip <= 0)
03546          for (ig = 0; ig < ctl->ng; ig++)
03547              for (id = 0; id < ctl->nd; id++)
03548                  tau_path[ig][id] = 1;
03549
03550      /* Loop over channels... */
03551      for (id = 0; id < ctl->nd; id++) {
03552
03553          /* Initialize... */
03554          tau_seg[id] = 1;
03555
03556          /* Loop over emitters... */
03557          for (ig = 0; ig < ctl->ng; ig++) {
03558
03559              /* Check size of table (pressure)... */
03560              if (tbl->np[ig][id] < 2)
03561                  eps = 0;
03562
03563              /* Check transmittance... */
03564              else if (tau_path[ig][id] < 1e-9)
03565                  eps = 1;
03566
03567              /* Interpolate... */
03568              else {
03569
03570                  /* Determine pressure and temperature indices... */
03571                  ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572                  it0 =
03573                      locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
03574                          t[ip]);
03575                  it1 =
03576                      locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03577                          los->t[ip]);

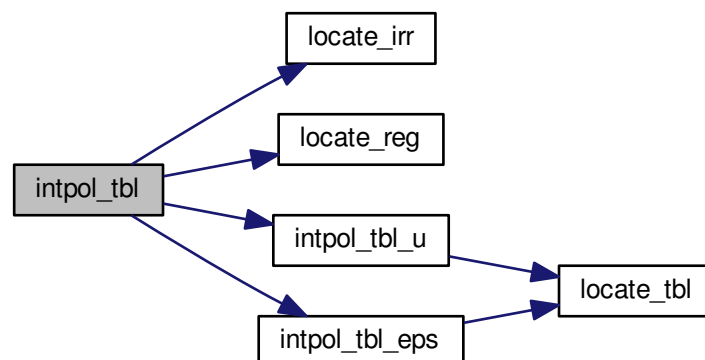
```

```

03577
03578 /* Check size of table (temperature and column density)... */
03579 if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03580     || tbl->nu[ig][id][ipr][it0] < 2
03581     || tbl->nu[ig][id][ipr][it0 + 1] < 2
03582     || tbl->nu[ig][id][ipr + 1][it1] < 2
03583     || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03584     eps = 0;
03585
03586 else {
03587
03588     /* Get emissivities of extended path... */
03589     u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590     eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592     u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593     eps01 =
03594         intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596     u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597     eps10 =
03598         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600     u =
03601         intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);
03602     eps11 =
03603         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
03604         u[ig][ip]);
03605
03606     /* Interpolate with respect to temperature... */
03607     eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03608                 tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03609     eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03610                 tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03611
03612     /* Interpolate with respect to pressure... */
03613     eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03614                 tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03615
03616     /* Check emssivity range... */
03617     eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03618
03619     /* Determine segment emissivity... */
03620     eps = 1 - (1 - eps00) / tau_path[ig][id];
03621 }
03622
03623 /* Get transmittance of extended path... */
03624 tau_path[ig][id] *= (1 - eps);
03625
03626 /* Get segment transmittance... */
03627 tau_seg[id] *= (1 - eps);
03628 }
03629 }
03630 }

```

Here is the call graph for this function:



5.13.2.24 double intpol\_tbl\_eps ( tbl\_t \* *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *u* )

Interpolate emissivity from look-up tables.

Definition at line 3634 of file [jurassic.c](#).

```

03640         {
03641
03642     int idx;
03643
03644     /* Lower boundary... */
03645     if (u < tbl->u[ig][id][ip][it][0])
03646         return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647             u);
03648
03649     /* Upper boundary... */
03650     else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651         return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652             tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653             1e30, 1, u);
03654
03655     /* Interpolation... */
03656     else {
03657
03658         /* Get index... */
03659         idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661         /* Interpolate... */
03662         return
03663             LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664                 tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665                 u);
03666     }
03667 }

```

Here is the call graph for this function:

5.13.2.25 double intpol\_tbl\_u ( tbl\_t \* *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *eps* )

Interpolate column density from look-up tables.

Definition at line 3671 of file [jurassic.c](#).

```

03677         {
03678
03679     int idx;
03680
03681     /* Lower boundary... */
03682     if (eps < tbl->eps[ig][id][ip][it][0])
03683         return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684             eps);
03685
03686     /* Upper boundary... */
03687     else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03688         return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689             tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690             1, 1e30, eps);
03691

```



```

03692  /* Interpolation... */
03693  else {
03694
03695      /* Get index... */
03696      idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698      /* Interpolate... */
03699      return
03700      LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701         tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702         eps);
03703  }
03704 }

```

Here is the call graph for this function:



**5.13.2.26** void jsec2time ( double *jsec*, int \* *year*, int \* *mon*, int \* *day*, int \* *hour*, int \* *min*, int \* *sec*, double \* *remain* )

Convert seconds to date.

Definition at line 3708 of file [jurassic.c](#).

```

03716      {
03717
03718      struct tm t0, *t1;
03719
03720      time_t jsec0;
03721
03722      t0.tm_year = 100;
03723      t0.tm_mon = 0;
03724      t0.tm_mday = 1;
03725      t0.tm_hour = 0;
03726      t0.tm_min = 0;
03727      t0.tm_sec = 0;
03728
03729      jsec0 = (time_t) jsec + timegm(&t0);
03730      t1 = gmtime(&jsec0);
03731
03732      *year = t1->tm_year + 1900;
03733      *mon = t1->tm_mon + 1;
03734      *day = t1->tm_mday;
03735      *hour = t1->tm_hour;
03736      *min = t1->tm_min;
03737      *sec = t1->tm_sec;
03738      *remain = jsec - floor(jsec);
03739  }

```

**5.13.2.27** void kernel ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, gsl\_matrix \* *k* )

Compute Jacobians.

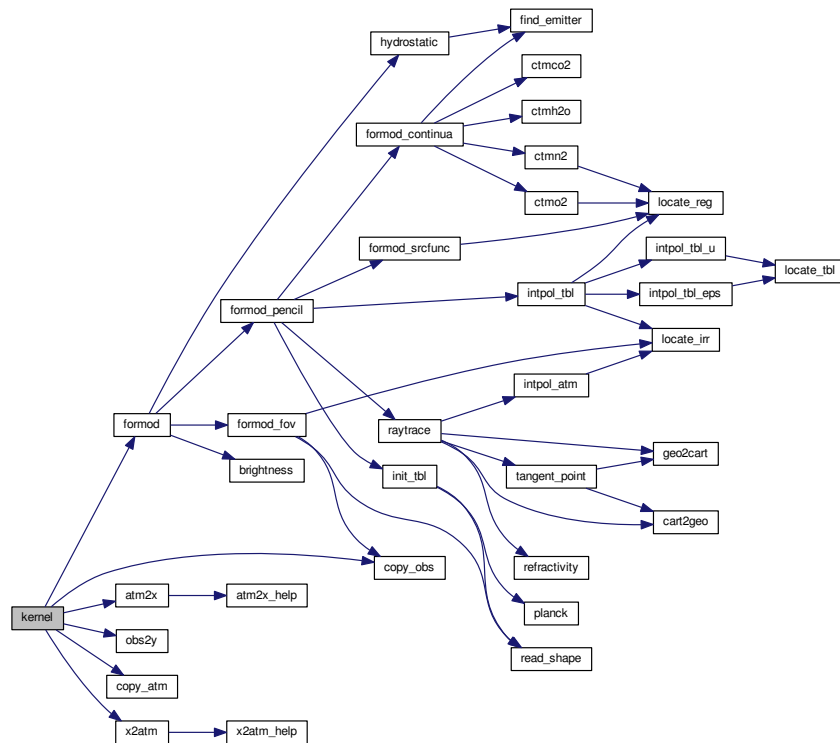
Definition at line 3743 of file [jurassic.c](#).

```

03747         {
03748
03749     atm_t *atml;
03750     obs_t *obs1;
03751
03752     gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754     int *iqa, j;
03755
03756     double h;
03757
03758     size_t i, n, m;
03759
03760     /* Get sizes... */
03761     m = k->size1;
03762     n = k->size2;
03763
03764     /* Allocate... */
03765     x0 = gsl_vector_alloc(n);
03766     yy0 = gsl_vector_alloc(m);
03767     ALLOC(iqa, int,
03768           N);
03769
03770     /* Compute radiance for undisturbed atmospheric data... */
03771     formod(ctl, atm, obs);
03772
03773     /* Compose vectors... */
03774     atm2x(ctl, atm, x0, iqa, NULL);
03775     obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777     /* Initialize kernel matrix... */
03778     gsl_matrix_set_zero(k);
03779
03780     /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atml,
03782     obs1)
03783     for (j = 0; j < (int) n; j++) {
03784
03785         /* Allocate... */
03786         x1 = gsl_vector_alloc(n);
03787         yy1 = gsl_vector_alloc(m);
03788         ALLOC(atml, atm_t, 1);
03789         ALLOC(obs1, obs_t, 1);
03790
03791         /* Set perturbation size... */
03792         if (iqa[j] == IDXP)
03793             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03794         else if (iqa[j] == IDXT)
03795             h = 1;
03796         else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03797             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03798         else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03799             h = 1e-4;
03800         else
03801             ERRMSG("Cannot set perturbation size!");
03802
03803         /* Disturb state vector element... */
03804         gsl_vector_memcpy(x1, x0);
03805         gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03806         copy_atm(ctl, atml, atm, 0);
03807         copy_obs(ctl, obs1, obs, 0);
03808         x2atm(ctl, x1, atml);
03809
03810         /* Compute radiance for disturbed atmospheric data... */
03811         formod(ctl, atml, obs1);
03812
03813         /* Compose measurement vector for disturbed radiance data... */
03814         obs2y(ctl, obs1, yy1, NULL, NULL);
03815
03816         /* Compute derivatives... */
03817         for (i = 0; i < m; i++)
03818             gsl_matrix_set(k, i, (size_t) j,
03819                           (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03820
03821         /* Free... */
03822         gsl_vector_free(x1);
03823         gsl_vector_free(yy1);
03824         free(atml);
03825         free(obs1);
03826     }
03827
03828     /* Free... */
03829     gsl_vector_free(x0);
03830     gsl_vector_free(yy0);
03831     free(iqa);
03832 }

```

Here is the call graph for this function:



#### 5.13.2.28 int locate\_irr ( double \* xx, int n, double x )

Find array index for irregular grid.

Definition at line 3835 of file [jurassic.c](#).

```

03838     {
03839
03840     int i, ilo, ihi;
03841
03842     ilo = 0;
03843     ihi = n - 1;
03844     i = (ihi + ilo) >> 1;
03845
03846     if (xx[i] < xx[i + 1])
03847         while (ihi > ilo + 1) {
03848             i = (ihi + ilo) >> 1;
03849             if (xx[i] > x)
03850                 ihi = i;
03851             else
03852                 ilo = i;
03853         } else
03854             while (ihi > ilo + 1) {
03855                 i = (ihi + ilo) >> 1;
03856                 if (xx[i] <= x)
03857                     ihi = i;
03858                 else
03859                     ilo = i;
03860             }
03861     return ilo;
03862 }
03863 }
```

## 5.13.2.29 int locate\_reg ( double \* xx, int n, double x )

Find array index for regular grid.

Definition at line 3867 of file [jurassic.c](#).

```

03870         {
03871
03872     int i;
03873
03874     /* Calculate index... */
03875     i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877     /* Check range... */
03878     if (i < 0)
03879         i = 0;
03880     else if (i >= n - 2)
03881         i = n - 2;
03882
03883     return i;
03884 }
```

## 5.13.2.30 int locate\_tbl ( float \* xx, int n, double x )

Find array index in float array.

Definition at line 3888 of file [jurassic.c](#).

```

03891         {
03892
03893     int i, ilo, ihi;
03894
03895     ilo = 0;
03896     ihi = n - 1;
03897     i = (ihi + ilo) >> 1;
03898
03899     while (ihi > ilo + 1) {
03900         i = (ihi + ilo) >> 1;
03901         if (xx[i] > x)
03902             ihi = i;
03903         else
03904             ilo = i;
03905     }
03906
03907     return ilo;
03908 }
```

## 5.13.2.31 size\_t obs2y ( ctl\_t \* ctl, obs\_t \* obs, gsl\_vector \* y, int \* ida, int \* ira )

Compose measurement vector.

Definition at line 3912 of file [jurassic.c](#).

```

03917         {
03918
03919     int id, ir;
03920
03921     size_t m = 0;
03922
03923     /* Determine measurement vector... */
03924     for (ir = 0; ir < obs->nr; ir++)
03925         for (id = 0; id < ctl->nd; id++)
03926             if (gsl_finite(obs->rad[id][ir])) {
03927                 if (y != NULL)
03928                     gsl_vector_set(y, m, obs->rad[id][ir]);
03929                 if (ida != NULL)
03930                     ida[m] = id;
03931                 if (ira != NULL)
03932                     ira[m] = ir;
03933                 m++;
03934             }
03935
03936     return m;
03937 }
```

### 5.13.2.32 double planck ( double *t*, double *nu* )

Compute Planck function.

Definition at line 3941 of file [jurassic.c](#).

```
03943     {
03944
03945     return C1 * POW3(nu) / gsl_expml(C2 * nu / t);
03946 }
```

### 5.13.2.33 void raytrace ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, los\_t \* *los*, int *ir* )

Do ray-tracing to determine LOS.

Definition at line 3950 of file [jurassic.c](#).

```
03955     {
03956
03957     double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958     lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959     xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961     int i, ig, ip, iw, stop = 0;
03962
03963     /* Initialize... */
03964     los->np = 0;
03965     los->tsurf = -999;
03966     obs->tpz[ir] = obs->vpz[ir];
03967     obs->tplon[ir] = obs->vplon[ir];
03968     obs->tplat[ir] = obs->vplat[ir];
03969
03970     /* Get altitude range of atmospheric data... */
03971     gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973     /* Check observer altitude... */
03974     if (obs->obsz[ir] < zmin)
03975         ERRMSG("Observer below surface!");
03976
03977     /* Check view point altitude... */
03978     if (obs->vpz[ir] > zmax)
03979         return;
03980
03981     /* Determine Cartesian coordinates for observer and view point... */
03982     geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983     geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985     /* Determine initial tangent vector... */
03986     for (i = 0; i < 3; i++)
03987         ex0[i] = xvp[i] - xobs[i];
03988     norm = NORM(ex0);
03989     for (i = 0; i < 3; i++)
03990         ex0[i] /= norm;
03991
03992     /* Observer within atmosphere... */
03993     for (i = 0; i < 3; i++)
03994         x[i] = xobs[i];
03995
03996     /* Observer above atmosphere (search entry point)... */
03997     if (obs->obsz[ir] > zmax) {
03998         dmax = norm;
03999         while (fabs(dmin - dmax) > 0.001) {
04000             d = (dmax + dmin) / 2;
04001             for (i = 0; i < 3; i++)
04002                 x[i] = xobs[i] + d * ex0[i];
04003             cart2geo(x, &z, &lon, &lat);
04004             if (z <= zmax && z > zmax - 0.001)
04005                 break;
04006             if (z < zmax - 0.0005)
04007                 dmax = d;
04008             else
04009                 dmin = d;
04010         }
04011     }
04012
04013     /* Ray-tracing... */
```

```

04014 while (1) {
04015
04016     /* Set step length... */
04017     ds = ctl->rayds;
04018     if (ctl->raydz > 0) {
04019         norm = NORM(x);
04020         for (i = 0; i < 3; i++)
04021             xh[i] = x[i] / norm;
04022         cosa = fabs(DOTP(ex0, xh));
04023         if (cosa != 0)
04024             ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025     }
04026
04027     /* Determine geolocation... */
04028     cart2geo(x, &z, &lon, &lat);
04029
04030     /* Check if LOS hits the ground or has left atmosphere... */
04031     if (z < zmin || z > zmax) {
04032         stop = (z < zmin ? 2 : 1);
04033         frac =
04034             ((z <
04035              zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                           1]);
04037         geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038                 los->lat[los->np - 1], xh);
04039         for (i = 0; i < 3; i++)
04040             x[i] = xh[i] + frac * (x[i] - xh[i]);
04041         cart2geo(x, &z, &lon, &lat);
04042         los->ds[los->np - 1] = ds * frac;
04043         ds = 0;
04044     }
04045
04046     /* Interpolate atmospheric data... */
04047     intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049     /* Save data... */
04050     los->lon[los->np] = lon;
04051     los->lat[los->np] = lat;
04052     los->z[los->np] = z;
04053     los->p[los->np] = p;
04054     los->t[los->np] = t;
04055     for (ig = 0; ig < ctl->ng; ig++)
04056         los->q[ig][los->np] = q[ig];
04057     for (iw = 0; iw < ctl->nw; iw++)
04058         los->k[iw][los->np] = k[iw];
04059     los->ds[los->np] = ds;
04060
04061     /* Increment and check number of LOS points... */
04062     if ((++los->np) > NLOS)
04063         ERRMSG("Too many LOS points!");
04064
04065     /* Check stop flag... */
04066     if (stop) {
04067         los->tsurf = (stop == 2 ? t : -999);
04068         break;
04069     }
04070
04071     /* Determine refractivity... */
04072     if (ctl->refrac && z <= zrefrac)
04073         n = 1 + refractivity(p, t);
04074     else
04075         n = 1;
04076
04077     /* Construct new tangent vector (first term)... */
04078     for (i = 0; i < 3; i++)
04079         exl[i] = ex0[i] * n;
04080
04081     /* Compute gradient of refractivity... */
04082     if (ctl->refrac && z <= zrefrac) {
04083         for (i = 0; i < 3; i++)
04084             xh[i] = x[i] + 0.5 * ds * ex0[i];
04085         cart2geo(xh, &z, &lon, &lat);
04086         intpol_atm(ctl, atm, z, &p, &t, q, k);
04087         n = refractivity(p, t);
04088         for (i = 0; i < 3; i++) {
04089             xh[i] += h;
04090             cart2geo(xh, &z, &lon, &lat);
04091             intpol_atm(ctl, atm, z, &p, &t, q, k);
04092             naux = refractivity(p, t);
04093             ng[i] = (naux - n) / h;
04094             xh[i] -= h;
04095         }
04096     } else
04097         for (i = 0; i < 3; i++)
04098             ng[i] = 0;
04099
04100     /* Construct new tangent vector (second term)... */

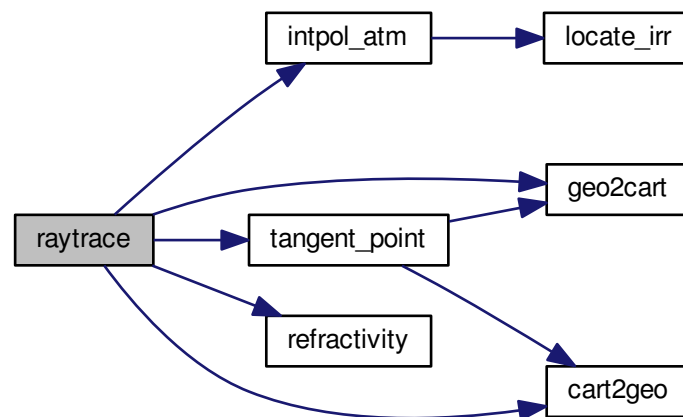
```

```

04101     for (i = 0; i < 3; i++)
04102         exl[i] += ds * ng[i];
04103
04104     /* Normalize new tangent vector... */
04105     norm = NORM(exl);
04106     for (i = 0; i < 3; i++)
04107         exl[i] /= norm;
04108
04109     /* Determine next point of LOS... */
04110     for (i = 0; i < 3; i++)
04111         x[i] += 0.5 * ds * (ex0[i] + exl[i]);
04112
04113     /* Copy tangent vector... */
04114     for (i = 0; i < 3; i++)
04115         ex0[i] = exl[i];
04116 }
04117
04118 /* Get tangent point (to be done before changing segment lengths!)... */
04119 tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
04120             tplat[ir]);
04121
04122 /* Change segment lengths according to trapezoid rule... */
04123 for (ip = los->np - 1; ip >= 1; ip--)
04124     los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04125 los->ds[0] *= 0.5;
04126
04127 /* Compute column density... */
04128 for (ip = 0; ip < los->np; ip++)
04129     for (ig = 0; ig < ctl->ng; ig++)
04130         los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04131         / (KB * los->t[ip] * los->ds[ip];
04132 }

```

Here is the call graph for this function:



**5.13.2.34** void read\_atm ( const char \* *dirname*, const char \* *filename*, ctl\_t \* *ctl*, atm\_t \* *atm* )

Read atmospheric data.

Definition at line 4135 of file [jurassic.c](#).

```

04139     {
04140
04141     FILE *in;
04142
04143     char file[LEN], line[LEN], *tok;

```

```

04144
04145     int ig, iw;
04146
04147     /* Init... */
04148     atm->np = 0;
04149
04150     /* Set filename... */
04151     if (dirname != NULL)
04152         sprintf(file, "%s/%s", dirname, filename);
04153     else
04154         sprintf(file, "%s", filename);
04155
04156     /* Write info... */
04157     printf("Read atmospheric data: %s\n", file);
04158
04159     /* Open file... */
04160     if (!(in = fopen(file, "r")))
04161         ERRMSG("Cannot open file!");
04162
04163     /* Read line... */
04164     while (fgets(line, LEN, in)) {
04165
04166         /* Read data... */
04167         TOK(line, tok, "%lg", atm->time[atm->np]);
04168         TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169         TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170         TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171         TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172         TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173         for (ig = 0; ig < ctl->ng; ig++)
04174             TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175         for (iw = 0; iw < ctl->nw; iw++)
04176             TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178         /* Increment data point counter... */
04179         if ((++atm->np) > NP)
04180             ERRMSG("Too many data points!");
04181     }
04182
04183     /* Close file... */
04184     fclose(in);
04185
04186     /* Check number of points... */
04187     if (atm->np < 1)
04188         ERRMSG("Could not read any data!");
04189 }

```

#### 5.13.2.35 void read\_ctl ( int argc, char \* argv[], ctl\_t \* ctl )

Read forward model control parameters.

Definition at line 4193 of file [jurassic.c](#).

```

04196     {
04197
04198     int id, ig, iw;
04199
04200     /* Write info... */
04201     printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202           "(executable: %s | compiled: %s, %s)\n\n",
04203           argv[0], __DATE__, __TIME__);
04204
04205     /* Emitters... */
04206     ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207     if (ctl->ng < 0 || ctl->ng > NG)
04208         ERRMSG("Set 0 <= NG <= MAX!");
04209     for (ig = 0; ig < ctl->ng; ig++)
04210         scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212     /* Radiance channels... */
04213     ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214     if (ctl->nd < 0 || ctl->nd > ND)
04215         ERRMSG("Set 0 <= ND <= MAX!");
04216     for (id = 0; id < ctl->nd; id++)
04217         ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219     /* Spectral windows... */
04220     ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221     if (ctl->nw < 0 || ctl->nw > NW)
04222         ERRMSG("Set 0 <= NW <= MAX!");

```



```

04223     for (id = 0; id < ctl->nd; id++)
04224         ctl->window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226     /* Emissivity look-up tables... */
04227     scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229     /* Hydrostatic equilibrium... */
04230     ctl->hydZ = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232     /* Continua... */
04233     ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234     ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235     ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236     ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238     /* Ray-tracing... */
04239     ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240     ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241     ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243     /* Field of view... */
04244     scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246     /* Retrieval interface... */
04247     ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248     ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249     ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250     ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251     for (ig = 0; ig < ctl->ng; ig++) {
04252         ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253         ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254     }
04255     for (iw = 0; iw < ctl->nw; iw++) {
04256         ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257         ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258     }
04259
04260     /* Output flags... */
04261     ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262     ctl->write_matrix =
04263         (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }

```

Here is the call graph for this function:



**5.13.2.36** void read\_matrix ( const char \* *dirname*, const char \* *filename*, gsl\_matrix \* *matrix* )

Read matrix.

Definition at line 4268 of file [jurassic.c](#).

```

04271     {
04272
04273     FILE *in;
04274
04275     char dum[LEN], file[LEN], line[LEN];
04276
04277     double value;
04278
04279     int i, j;
04280
04281     /* Set filename... */

```

```

04282     if (dirname != NULL)
04283         sprintf(file, "%s/%s", dirname, filename);
04284     else
04285         sprintf(file, "%s", filename);
04286
04287     /* Write info... */
04288     printf("Read matrix: %s\n", file);
04289
04290     /* Open file... */
04291     if (!(in = fopen(file, "r")))
04292         ERRMSG("Cannot open file!");
04293
04294     /* Read data... */
04295     gsl_matrix_set_zero(matrix);
04296     while (fgets(line, LEN, in))
04297         if (sscanf(line, "%d %s %s %s %s %s %d %s %s %s %s %s %lg",
04298             &i, dum, dum, dum, dum, dum,
04299             &j, dum, dum, dum, dum, dum, &value) == 13)
04300         gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302     /* Close file... */
04303     fclose(in);
04304 }

```

#### 5.13.2.37 void read\_obs ( const char \* *dirname*, const char \* *filename*, ctl\_t \* *ctl*, obs\_t \* *obs* )

Read observation data.

Definition at line 4308 of file [jurassic.c](#).

```

04312     {
04313
04314     FILE *in;
04315
04316     char file[LEN], line[LEN], *tok;
04317
04318     int id;
04319
04320     /* Init... */
04321     obs->nr = 0;
04322
04323     /* Set filename... */
04324     if (dirname != NULL)
04325         sprintf(file, "%s/%s", dirname, filename);
04326     else
04327         sprintf(file, "%s", filename);
04328
04329     /* Write info... */
04330     printf("Read observation data: %s\n", file);
04331
04332     /* Open file... */
04333     if (!(in = fopen(file, "r")))
04334         ERRMSG("Cannot open file!");
04335
04336     /* Read line... */
04337     while (fgets(line, LEN, in)) {
04338
04339         /* Read data... */
04340         TOK(line, tok, "%lg", obs->time[obs->nr]);
04341         TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342         TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343         TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344         TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345         TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346         TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347         TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348         TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349         TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350         for (id = 0; id < ctl->nd; id++)
04351             TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352         for (id = 0; id < ctl->nd; id++)
04353             TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355         /* Increment counter... */
04356         if ((++obs->nr) > NR)
04357             ERRMSG("Too many rays!");
04358     }
04359
04360     /* Close file... */
04361     fclose(in);

```

```

04362
04363  /* Check number of points... */
04364  if (obs->nr < 1)
04365      ERRMSG("Could not read any data!");
04366  }

```

#### 5.13.2.38 void read\_shape ( const char \* filename, double \* x, double \* y, int \* n )

Read shape function.

Definition at line 4370 of file [jurassic.c](#).

```

04374      {
04375
04376      FILE *in;
04377
04378      char line[LEN];
04379
04380      /* Write info... */
04381      printf("Read shape function: %s\n", filename);
04382
04383      /* Open file... */
04384      if (!(in = fopen(filename, "r")))
04385          ERRMSG("Cannot open file!");
04386
04387      /* Read data... */
04388      *n = 0;
04389      while (fgets(line, LEN, in))
04390          if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391              if (++(*n) > NSHAPE)
04392                  ERRMSG("Too many data points!");
04393
04394      /* Check number of points... */
04395      if (*n < 1)
04396          ERRMSG("Could not read any data!");
04397
04398      /* Close file... */
04399      fclose(in);
04400  }

```

#### 5.13.2.39 double refractivity ( double p, double t )

Compute refractivity (return value is n - 1).

Definition at line 4404 of file [jurassic.c](#).

```

04406      {
04407
04408      /* Refractivity of air at 4 to 15 micron... */
04409      return 7.753e-05 * p / t;
04410  }

```

#### 5.13.2.40 double scan\_ctl ( int argc, char \* argv[], const char \* varname, int arridx, const char \* defvalue, char \* value )

Search control parameter file for variable entry.

Definition at line 4414 of file [jurassic.c](#).

```

04420         {
04421
04422     FILE *in = NULL;
04423
04424     char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425         msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427     int contain = 0, i;
04428
04429     /* Open file... */
04430     if (argv[1][0] != '-')
04431         if (!(in = fopen(argv[1], "r")))
04432             ERRMSG("Cannot open file!");
04433
04434     /* Set full variable name... */
04435     if (arridx >= 0) {
04436         sprintf(fullname1, "%s[%d]", varname, arridx);
04437         sprintf(fullname2, "%s[*]", varname);
04438     } else {
04439         sprintf(fullname1, "%s", varname);
04440         sprintf(fullname2, "%s", varname);
04441     }
04442
04443     /* Read data... */
04444     if (in != NULL)
04445         while (fgets(line, LEN, in))
04446             if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447                 if (strcascmp(rvarname, fullname1) == 0 ||
04448                     strcascmp(rvarname, fullname2) == 0) {
04449                     contain = 1;
04450                     break;
04451                 }
04452     for (i = 1; i < argc - 1; i++)
04453         if (strcascmp(argv[i], fullname1) == 0 ||
04454             strcascmp(argv[i], fullname2) == 0) {
04455             sprintf(rval, "%s", argv[i + 1]);
04456             contain = 1;
04457             break;
04458         }
04459
04460     /* Close file... */
04461     if (in != NULL)
04462         fclose(in);
04463
04464     /* Check for missing variables... */
04465     if (!contain) {
04466         if (strlen(defvalue) > 0)
04467             sprintf(rval, "%s", defvalue);
04468         else {
04469             sprintf(msg, "Missing variable %s!\n", fullname1);
04470             ERRMSG(msg);
04471         }
04472     }
04473
04474     /* Write info... */
04475     printf("%s = %s\n", fullname1, rval);
04476
04477     /* Return values... */
04478     if (value != NULL)
04479         sprintf(value, "%s", rval);
04480     return atof(rval);
04481 }

```

#### 5.13.2.41 void tangent\_point ( los\_t \* los, double \* tpz, double \* tplon, double \* tplat )

Find tangent point of a given LOS.

Definition at line 4485 of file [jurassic.c](#).

```

04489         {
04490
04491     double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493     size_t i, ip;
04494
04495     /* Find minimum altitude... */
04496     ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498     /* Nadir or zenith... */
04499     if (ip <= 0 || ip >= (size_t) los->np - 1) {

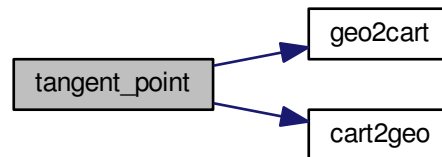
```

```

04500     *tpz = los->z[los->np - 1];
04501     *tplon = los->lon[los->np - 1];
04502     *tplat = los->lat[los->np - 1];
04503 }
04504
04505 /* Limb... */
04506 else {
04507
04508     /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509     yy0 = los->z[ip - 1];
04510     yy1 = los->z[ip];
04511     yy2 = los->z[ip + 1];
04512     x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513     x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514     a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515     b = -(yy0 - yy1) / x1 - a * x1;
04516     c = yy0;
04517
04518     /* Get tangent point location... */
04519     x = -b / (2 * a);
04520     *tpz = a * x * x + b * x + c;
04521     geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522     geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523     for (i = 0; i < 3; i++)
04524         v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525     cart2geo(v, &dummy, tplon, tplat);
04526 }
04527 }

```

Here is the call graph for this function:



**5.13.2.42** void time2jsec ( int year, int mon, int day, int hour, int min, int sec, double remain, double \* jsec )

Convert date to seconds.

Definition at line 4531 of file [jurassic.c](#).

```

04539     {
04540
04541     struct tm t0, t1;
04542
04543     t0.tm_year = 100;
04544     t0.tm_mon = 0;
04545     t0.tm_mday = 1;
04546     t0.tm_hour = 0;
04547     t0.tm_min = 0;
04548     t0.tm_sec = 0;
04549
04550     t1.tm_year = year - 1900;
04551     t1.tm_mon = mon - 1;
04552     t1.tm_mday = day;
04553     t1.tm_hour = hour;
04554     t1.tm_min = min;
04555     t1.tm_sec = sec;
04556
04557     *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }

```

## 5.13.2.43 void timer ( const char \* name, const char \* file, const char \* func, int line, int mode )

Measure wall-clock time.

Definition at line 4562 of file [jurassic.c](#).

```

04567         {
04568
04569     static double w0[10];
04570
04571     static int l0[10], nt;
04572
04573     /* Start new timer... */
04574     if (mode == 1) {
04575         w0[nt] = omp_get_wtime();
04576         l0[nt] = line;
04577         if ((++nt) >= 10)
04578             ERRMSG("Too many timers!");
04579     }
04580
04581     /* Write elapsed time... */
04582     else {
04583
04584         /* Check timer index... */
04585         if (nt - 1 < 0)
04586             ERRMSG("Coding error!");
04587
04588         /* Write elapsed time... */
04589         printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590             name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591     }
04592
04593     /* Stop timer... */
04594     if (mode == 3)
04595         nt--;
04596 }

```

## 5.13.2.44 void write\_atm ( const char \* dirname, const char \* filename, ctl\_t \* ctl, atm\_t \* atm )

Write atmospheric data.

Definition at line 4600 of file [jurassic.c](#).

```

04604         {
04605
04606     FILE *out;
04607
04608     char file[LEN];
04609
04610     int ig, ip, iw, n = 6;
04611
04612     /* Set filename... */
04613     if (dirname != NULL)
04614         sprintf(file, "%s/%s", dirname, filename);
04615     else
04616         sprintf(file, "%s", filename);
04617
04618     /* Write info... */
04619     printf("Write atmospheric data: %s\n", file);
04620
04621     /* Create file... */
04622     if (!(out = fopen(file, "w")))
04623         ERRMSG("Cannot create file!");
04624
04625     /* Write header... */
04626     fprintf(out,
04627         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628         "# $2 = altitude [km]\n"
04629         "# $3 = longitude [deg]\n"
04630         "# $4 = latitude [deg]\n"
04631         "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632     for (ig = 0; ig < ctl->ng; ig++)
04633         fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634     for (iw = 0; iw < ctl->nw; iw++)
04635         fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636 }

```

```

04637  /* Write data... */
04638  for (ip = 0; ip < atm->np; ip++) {
04639      if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640          || atm->lon[ip] != atm->lon[ip - 1])
04641          fprintf(out, "\n");
04642      fprintf(out, "%.2f %g %g %g %g", atm->time[ip], atm->z[ip],
04643          atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644      for (ig = 0; ig < ctl->ng; ig++)
04645          fprintf(out, " %g", atm->q[ig][ip]);
04646      for (iw = 0; iw < ctl->nw; iw++)
04647          fprintf(out, " %g", atm->k[iw][ip]);
04648      fprintf(out, "\n");
04649  }
04650
04651  /* Close file... */
04652  fclose(out);
04653 }

```

**5.13.2.45** `void write_matrix ( const char * dirname, const char * filename, ctl_t * ctl, gsl_matrix * matrix, atm_t * atm, obs_t * obs, const char * row_space, const char * col_space, const char * sort )`

Write matrix.

Definition at line 4657 of file [jurassic.c](#).

```

04666      {
04667
04668      FILE *out;
04669
04670      char file[LEN], quantity[LEN];
04671
04672      int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674      size_t i, j, nc, nr;
04675
04676      /* Check output flag... */
04677      if (!ctl->write_matrix)
04678          return;
04679
04680      /* Allocate... */
04681      ALLOC(cida, int, M);
04682      ALLOC(ciqa, int,
04683          N);
04684      ALLOC(cipa, int,
04685          N);
04686      ALLOC(cira, int,
04687          M);
04688      ALLOC(rida, int,
04689          M);
04690      ALLOC(riqa, int,
04691          N);
04692      ALLOC(ripa, int,
04693          N);
04694      ALLOC(rira, int,
04695          M);
04696
04697      /* Set filename... */
04698      if (dirname != NULL)
04699          sprintf(file, "%s/%s", dirname, filename);
04700      else
04701          sprintf(file, "%s", filename);
04702
04703      /* Write info... */
04704      printf("Write matrix: %s\n", file);
04705
04706      /* Create file... */
04707      if (!(out = fopen(file, "w")))
04708          ERRMSG("Cannot create file!");
04709
04710      /* Write header (row space)... */
04711      if (row_space[0] == 'y') {
04712          fprintf(out,
04713              "# $1 = Row: index (measurement space)\n"
04714              "# $2 = Row: channel wavenumber [cm^-1]\n"
04715              "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04716              "# $4 = Row: view point altitude [km]\n"
04717              "# $5 = Row: view point longitude [deg]\n"
04718              "# $6 = Row: view point latitude [deg]\n");
04719
04720

```

```

04721      /* Get number of rows... */
04722      nr = obs2y(ctl, obs, NULL, rida, rira);
04723
04724  } else {
04725
04726      fprintf(out,
04727              "# $1 = Row: index (state space)\n"
04728              "# $2 = Row: name of quantity\n"
04729              "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04730              "# $4 = Row: altitude [km]\n"
04731              "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733      /* Get number of rows... */
04734      nr = atm2x(ctl, atm, NULL, riq, ripa);
04735  }
04736
04737  /* Write header (column space)... */
04738  if (colspace[0] == 'y') {
04739
04740      fprintf(out,
04741              "# $7 = Col: index (measurement space)\n"
04742              "# $8 = Col: channel wavenumber [cm^-1]\n"
04743              "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04744              "# $10 = Col: view point altitude [km]\n"
04745              "# $11 = Col: view point longitude [deg]\n"
04746              "# $12 = Col: view point latitude [deg]\n");
04747
04748      /* Get number of columns... */
04749      nc = obs2y(ctl, obs, NULL, cida, cira);
04750
04751  } else {
04752
04753      fprintf(out,
04754              "# $7 = Col: index (state space)\n"
04755              "# $8 = Col: name of quantity\n"
04756              "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04757              "# $10 = Col: altitude [km]\n"
04758              "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04759
04760      /* Get number of columns... */
04761      nc = atm2x(ctl, atm, NULL, cira, cipa);
04762  }
04763
04764  /* Write header entry... */
04765  fprintf(out, "# $13 = Matrix element\n\n");
04766
04767  /* Write matrix data... */
04768  i = j = 0;
04769  while (i < nr && j < nc) {
04770
04771      /* Write info about the row... */
04772      if (rowspace[0] == 'y')
04773          fprintf(out, "%d %g %.2f %g %g %g",
04774                  (int) i, ctl->nu[rida[i]],
04775                  obs->time[rira[i]], obs->vpz[rira[i]],
04776                  obs->vplon[rira[i]], obs->vplat[rira[i]]);
04777      else {
04778          idx2name(ctl, riq[i], quantity);
04779          fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04780                  atm->time[ripa[i]], atm->z[ripa[i]],
04781                  atm->lon[ripa[i]], atm->lat[ripa[i]]);
04782      }
04783
04784      /* Write info about the column... */
04785      if (colspace[0] == 'y')
04786          fprintf(out, " %d %g %.2f %g %g %g",
04787                  (int) j, ctl->nu[cida[j]],
04788                  obs->time[cira[j]], obs->vpz[cira[j]],
04789                  obs->vplon[cira[j]], obs->vplat[cira[j]]);
04790      else {
04791          idx2name(ctl, cira[j], quantity);
04792          fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04793                  atm->time[cipa[j]], atm->z[cipa[j]],
04794                  atm->lon[cipa[j]], atm->lat[cipa[j]]);
04795      }
04796
04797      /* Write matrix entry... */
04798      fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04799
04800      /* Set matrix indices... */
04801      if (sort[0] == 'r') {
04802          j++;
04803          if (j >= nc) {
04804              j = 0;
04805              i++;
04806              fprintf(out, "\n");
04807          }
04808      }

```

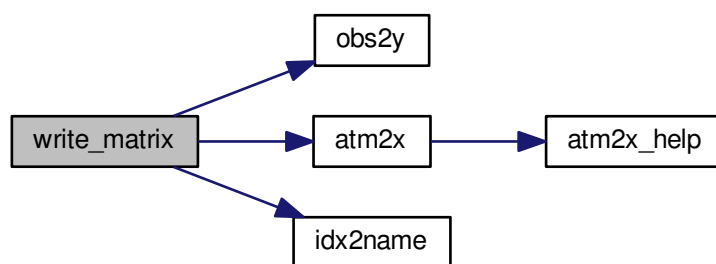


```

04808     } else {
04809         i++;
04810         if (i >= nr) {
04811             i = 0;
04812             j++;
04813             fprintf(out, "\n");
04814         }
04815     }
04816 }
04817
04818 /* Close file... */
04819 fclose(out);
04820
04821 /* Free... */
04822 free(cida);
04823 free(ciga);
04824 free(cipa);
04825 free(cira);
04826 free(rida);
04827 free(riqa);
04828 free(ripa);
04829 free(rira);
04830 }

```

Here is the call graph for this function:



**5.13.2.46** `void write_obs ( const char * dirname, const char * filename, ctl_t * ctl, obs_t * obs )`

Write observation data.

Definition at line [4834](#) of file [jurassic.c](#).

```

04838     {
04839
04840     FILE *out;
04841
04842     char file[LEN];
04843
04844     int id, ir, n = 10;
04845
04846     /* Set filename... */
04847     if (dirname != NULL)
04848         sprintf(file, "%s/%s", dirname, filename);
04849     else
04850         sprintf(file, "%s", filename);
04851
04852     /* Write info... */
04853     printf("Write observation data: %s\n", file);
04854
04855     /* Create file... */
04856     if (!(out = fopen(file, "w")))
04857         ERRMSG("Cannot create file!");
04858

```

```

04859  /* Write header... */
04860  fprintf(out,
04861          "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862          "# $2 = observer altitude [km]\n"
04863          "# $3 = observer longitude [deg]\n"
04864          "# $4 = observer latitude [deg]\n"
04865          "# $5 = view point altitude [km]\n"
04866          "# $6 = view point longitude [deg]\n"
04867          "# $7 = view point latitude [deg]\n"
04868          "# $8 = tangent point altitude [km]\n"
04869          "# $9 = tangent point longitude [deg]\n"
04870          "# $10 = tangent point latitude [deg]\n");
04871  for (id = 0; id < ctl->nd; id++)
04872      fprintf(out, "# $d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873              ++n, ctl->nu[id]);
04874  for (id = 0; id < ctl->nd; id++)
04875      fprintf(out, "# $d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877  /* Write data... */
04878  for (ir = 0; ir < obs->nr; ir++) {
04879      if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880          fprintf(out, "\n");
04881      fprintf(out, "%.2f %g %g %g %g %g %g %g %g", obs->time[ir],
04882              obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883              obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884              obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885      for (id = 0; id < ctl->nd; id++)
04886          fprintf(out, " %g", obs->rad[id][ir]);
04887      for (id = 0; id < ctl->nd; id++)
04888          fprintf(out, " %g", obs->tau[id][ir]);
04889      fprintf(out, "\n");
04890  }
04891
04892  /* Close file... */
04893  fclose(out);
04894 }

```

#### 5.13.2.47 void x2atm ( ctl\_t \* ctl, gsl\_vector \* x, atm\_t \* atm )

Decompose parameter vector or state vector.

Definition at line 4898 of file [jurassic.c](#).

```

04901      {
04902
04903      int ig, iw;
04904
04905      size_t n = 0;
04906
04907      /* Set pressure... */
04908      x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
04909                p, x, &n);
04909
04910      /* Set temperature... */
04911      x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
04912                t, x, &n);
04912
04913      /* Set volume mixing ratio... */
04914      for (ig = 0; ig < ctl->ng; ig++)
04915          x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916                    atm->q[ig], x, &n);
04917
04918      /* Set extinction... */
04919      for (iw = 0; iw < ctl->nw; iw++)
04920          x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921                    atm->k[iw], x, &n);
04922 }

```

Here is the call graph for this function:



#### 5.13.2.48 void x2atm\_help ( atm\_t \* atm, double zmin, double zmax, double \* value, gsl\_vector \* x, size\_t \* n )

Extract elements from state vector.

Definition at line 4926 of file jurassic.c.

```

04932         {
04933
04934     int ip;
04935
04936     /* Extract state vector elements... */
04937     for (ip = 0; ip < atm->np; ip++)
04938         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939             value[ip] = gsl_vector_get(x, *n);
04940             (*n)++;
04941         }
04942 }
```

#### 5.13.2.49 void y2obs ( ctl\_t \* ctl, gsl\_vector \* y, obs\_t \* obs )

Decompose measurement vector.

Definition at line 4946 of file jurassic.c.

```

04949         {
04950
04951     int id, ir;
04952
04953     size_t m = 0;
04954
04955     /* Decompose measurement vector... */
04956     for (ir = 0; ir < obs->nr; ir++)
04957         for (id = 0; id < ctl->nd; id++)
04958             if (gsl_finite(obs->rad[id][ir])) {
04959                 obs->rad[id][ir] = gsl_vector_get(y, m);
04960                 m++;
04961             }
04962 }
```

## 5.14 jurassic.c

```

00001 /*
00002  This file is part of JURASSIC.
00003
00004  JURASSIC is free software: you can redistribute it and/or modify
00005  it under the terms of the GNU General Public License as published by
00006  the Free Software Foundation, either version 3 of the License, or
00007  (at your option) any later version.
00008
00009  JURASSIC is distributed in the hope that it will be useful,
00010  but WITHOUT ANY WARRANTY; without even the implied warranty of
00011  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012  GNU General Public License for more details.
00013
00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /*****
00028
00029 size_t atm2x(
00030     ctl_t * ctl,
00031     atm_t * atm,
00032     gsl_vector * x,
00033     int *iga,
00034     int *ipa) {
00035
00036     int ig, iw;
```

```

00037
00038     size_t n = 0;
00039
00040     /* Add pressure... */
00041     atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042               atm->p, IDXP, x, iqa, ipa, &n);
00043
00044     /* Add temperature... */
00045     atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046               atm->t, IDXT, x, iqa, ipa, &n);
00047
00048     /* Add volume mixing ratios... */
00049     for (ig = 0; ig < ctl->ng; ig++)
00050         atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                   atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053     /* Add extinction... */
00054     for (iw = 0; iw < ctl->nw; iw++)
00055         atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                   atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058     return n;
00059 }
00060
00061 /*****
00062
00063 void atm2x_help(
00064     atm_t * atm,
00065     double zmin,
00066     double zmax,
00067     double *value,
00068     int val_iqa,
00069     gsl_vector * x,
00070     int *iqa,
00071     int *ipa,
00072     size_t * n) {
00073
00074     int ip;
00075
00076     /* Add elements to state vector... */
00077     for (ip = 0; ip < atm->np; ip++)
00078         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079             if (x != NULL)
00080                 gsl_vector_set(x, *n, value[ip]);
00081             if (iqa != NULL)
00082                 iqa[*n] = val_iqa;
00083             if (ipa != NULL)
00084                 ipa[*n] = ip;
00085             (*n)++;
00086         }
00087 }
00088
00089 /*****
00090
00091 double brightness(
00092     double rad,
00093     double nu) {
00094
00095     return C2 * nu / gsl_loglp(C1 * POW3(nu) / rad);
00096 }
00097
00098 /*****
00099
00100 void cart2geo(
00101     double *x,
00102     double *z,
00103     double *lon,
00104     double *lat) {
00105
00106     double radius;
00107
00108     radius = NORM(x);
00109     *lat = asin(x[2] / radius) * 180 / M_PI;
00110     *lon = atan2(x[1], x[0]) * 180 / M_PI;
00111     *z = radius - RE;
00112 }
00113
00114 /*****
00115
00116 void climatology(
00117     ctl_t * ctl,
00118     atm_t * atm) {
00119
00120     static double z[121] = {
00121         0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00122         20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,

```

```
00124      38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125      56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126      74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127      92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128      108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129  };
00130
00131  static double pre[121] = {
00132      1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133      357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134      104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135      29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136      10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137      3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138      1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139      0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140      0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141      0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142      0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143      0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144      0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145      0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146      0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147      0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148      9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149      4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150      2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151  };
00152
00153  static double tem[121] = {
00154      285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155      229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156      215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157      222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158      241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159      262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160      258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161      237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162      220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163      207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164      190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165      178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166      201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167      272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168  };
00169
00170  static double c2h2[121] = {
00171      1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172      2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173      5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174      2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175      9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176      1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177      1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178      1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179      2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183  };
00184
00185  static double c2h6[121] = {
00186      2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187      1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188      5.503e-10, 4.872e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189      2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190      2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191      1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192      5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193      2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194      1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195      7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,
00196      3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197      1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198      4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199      1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200      3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202      0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00203  };
00204
00205  static double cc14[121] = {
00206      1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207      1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208      8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209      3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210      3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
```

```
00211     4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220     1e-14, 1e-14, 1e-14
00221 };
00222
00223 static double ch4[121] = {
00224     1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225     1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226     1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227     1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228     1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229     8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230     6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231     4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232     3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233     2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234     1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235     1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236     1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237     9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238     7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239     5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240     4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241     3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242     2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243     2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244     1.782e-08
00245 };
00246
00247 static double clo[121] = {
00248     7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249     6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250     8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251     2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252     1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253     2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254     4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255     5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256     3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257     1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258     6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259     2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260     8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261     3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262     1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263     3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264     1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265     3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266     1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267     5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268     3.148e-15
00269 };
00270
00271 static double clono2[121] = {
00272     1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273     1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274     2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275     2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276     8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277     6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278     1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279     1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280     1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281     1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282     9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293 };
00294
00295 static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
```

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00298 5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299 2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300 1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301 2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302 3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303 3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304 6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305 2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306 8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307 2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308 3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309 6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310 1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311 1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312 3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313 5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314 6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315 7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05
00316 };
00317
00318 static double cof2[121] = {
00319 7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320 6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321 7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322 4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323 1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324 1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325 1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326 8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327 5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328 2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329 7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330 1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331 4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332 1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333 2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334 4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335 7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336 1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337 3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338 1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339 4.662e-18
00340 };
00341
00342 static double f11[121] = {
00343 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345 2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346 1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347 7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348 5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349 1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350 3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351 6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352 1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353 1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354 2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355 2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356 2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357 2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358 1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359 1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360 1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361 2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362 4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363 };
00364
00365 static double f12[121] = {
00366 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368 5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369 4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
00370 2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371 5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372 2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373 8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374 3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375 1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376 8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377 4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378 2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379 9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380 4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381 1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382 7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383 3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384 1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
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00385     1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386 };
00387
00388 static double f14[121] = {
00389     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391     8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00406 };
00407
00408 static double f22[121] = {
00409     1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410     1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411     1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412     7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413     4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414     3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415     1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416     1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417     8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418     5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419     4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420     3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421     3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422     2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423     2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424     2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425     1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426     1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427     1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428     1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429 };
00430
00431 static double h2o[121] = {
00432     0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433     0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434     6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435     4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436     4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437     5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438     5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439     6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440     6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441     6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442     5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443     4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444     3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445     2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446     1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447     5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448     1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449     7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450     3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451     1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452 };
00453
00454 static double h2o2[121] = {
00455     1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456     4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
00457     3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458     1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459     8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460     1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461     1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462     6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463     5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464     4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465     3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466     2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467     1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468     1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469     9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470     7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471     4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
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00472      3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473      2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474      2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475      1.775e-12
00476  };
00477
00478  static double hcn[121] = {
00479      5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480      5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481      5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482      1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483      1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484      1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485      1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486      1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487      1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488      9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489      8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490      7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491      6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492      6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493      6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494      6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495      5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496      5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497      5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498      5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499  };
00500
00501  static double hno3[121] = {
00502      1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503      2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504      5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505      3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506      8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507      3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508      8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509      1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510      6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511      3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512      1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513      9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514      5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515      2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516      1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517      5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518      2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519      1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520      5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521      3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522      2.332e-14
00523  };
00524
00525  static double hno4[121] = {
00526      6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527      1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528      3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529      1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530      2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531      1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532      3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533      2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534      1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535      2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536      1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537      5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538      2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539      8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540      3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541      1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542      3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543      1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
00544      5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545      2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546      1.64e-18
00547  };
00548
00549  static double hocl[121] = {
00550      1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551      2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552      5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553      1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554      4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555      7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556      1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557      6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558      1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
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00559     3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560     6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561     1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562     1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563     2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564     3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565     4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566     5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567     6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568     9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569     2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570     7.881e-21
00571 };
00572
00573 static double n2o[121] = {
00574     3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575     3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576     2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577     2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578     1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579     7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580     2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581     1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582     5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583     2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584     1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585     1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586     9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587     7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588     5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589     4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590     3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591     2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592     2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593     2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594 };
00595
00596 static double n2o5[121] = {
00597     1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598     1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599     4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600     7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601     3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602     2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603     2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604     6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612     1e-16, 1e-16
00613 };
00614
00615 static double nh3[121] = {
00616     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617     1e-10, 1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618     4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619     5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620     6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621     1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622     1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623     1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624     2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00631     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635     1.914e-17
00636 };
00637
00638 static double no[121] = {
00639     2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640     1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641     7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642     1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643     8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644     5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645     1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,

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```
00646 1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647 9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648 3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649 8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650 1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651 2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652 1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653 7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654 6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655 3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656 1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657 5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658 9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659 0.0001133
00660 };
00661
00662 static double no2[121] = {
00663 3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664 2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665 9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666 9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667 3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668 7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669 7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670 2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671 2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672 3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673 6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674 9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675 2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676 1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681 };
00682
00683 static double o3[121] = {
00684 2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685 5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686 1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687 1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688 4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689 6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690 7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691 5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692 3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693 1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694 9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695 4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696 2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697 2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698 3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699 8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700 8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701 3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702 6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703 5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704 3.665e-10
00705 };
00706
00707 static double ocs[121] = {
00708 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709 5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710 4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711 1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712 1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713 5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714 1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00718 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727 1.091e-14, 1.091e-14, 1.091e-14
00728 };
00729
00730 static double sf6[121] = {
00731 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732 4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
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00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750 };
00751
00752 static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768 };
00769
00770 static int ig_co2 = -999;
00771
00772 double co2, *q[NG] = { NULL };
00773
00774 int ig, ip, iw, iz;
00775
00776 /* Find emitter index of CO2... */
00777 if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780 /* Identify variable... */
00781 for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784         q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786         q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788         q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790         q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792         q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794         q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796         q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798         q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800         q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802         q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804         q[ig] = f14;
00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806         q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808         q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810         q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812         q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814         q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816         q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOC1") == 0)
00818         q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)

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00820     q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822         q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824         q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826         q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828         q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830         q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832         q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834         q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836         q[ig] = so2;
00837 }
00838
00839 /* Loop over atmospheric data points... */
00840 for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853         if (q[ig] != NULL)
00854             atm->q[ig][ip] =
00855                 LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856         else
00857             atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861         co2 =
00862             371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863         atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868         atm->k[iw][ip] = 0;
00869 }
00870 }
00871
00872 /*****
00873
00874 double ctmc02(
00875     double nu,
00876     double p,
00877     double t,
00878     double u) {
00879
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01709    };
01710
01711    double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmph;
01712
01713    int iw;
01714
01715    /* Get CO2 continuum absorption... */
01716    xw = nu / 2 + 1;
01717    if (xw >= 1 && xw < 2001) {
01718        iw = (int) xw;
01719        dw = xw - iw;
01720        ew = 1 - dw;
01721        cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722        cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723        cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724        dt230 = t - 230;
01725        dt260 = t - 260;
01726        dt296 = t - 296;
01727        ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728            * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729        ctmph = u / NA / 1000 * p / P0 * ctw;
01730    } else
01731        ctmph = 0;
01732    return ctmph;
01733 }
01734
01735 /*****
01736
01737 double ctmh2o(
01738     double nu,
01739     double p,
01740     double t,
01741     double q,
01742     double u) {
01743
01744     static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745         .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746         .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747         .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748         .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749         .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750         .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
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01752         3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753         1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754         1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
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01759         1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
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02731 4.644e-15, 3.55e-15, 2.808e-15, 2.274e-15, 1.871e-15, 1.557e-15,  
02732 1.308e-15, 1.108e-15, 9.488e-16, 8.222e-16, 7.238e-16, 6.506e-16,  
02733 6.008e-16, 5.742e-16, 5.724e-16, 5.991e-16, 6.625e-16, 7.775e-16,

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02737     3.7e-13, 4.617e-13, 5.949e-13, 7.473e-13, 9.378e-13, 1.191e-12,
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02740     6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741     6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742     7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743     2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744     4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745 };
02746
02747 static double xfcrev[15] =
02748 { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749   1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750 };
02751
02752 double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753 sfac, fscal, cwfrn, ctmph, ctwfrn, ctws1f;
02754
02755 int iw, ix;
02756
02757 /* Get H2O continuum absorption... */
02758 xw = nu / 10 + 1;
02759 if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767         sfac = 1;
02768     } else {
02769         xx = (nu - 820) / 10;
02770         ix = (int) xx;
02771         dx = xx - ix;
02772         sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctws1f = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctws1f + (1 - q) * ctwfrn) * 1e-20;
02782     ctmph = a1 * a2 * a3;
02783 } else
02784     ctmph = 0;
02785 return ctmph;
02786 }
02787
02788 /*****
02789
02790 double ctmn2(
02791     double nu,
02792     double p,
02793     double t) {
02794
02795     static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796     1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797     2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798     5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799     7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800     9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801     1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802     1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803     1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804     1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805     7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806     3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807     1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808     7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809 };
02810
02811     static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812     511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813     233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814     -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815     -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816     -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817     -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818     121., 141., 152., 161., 164., 164., 161., 155., 148., 143., 137.,
02819     133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820     372., 449., 514., 569., 609., 642., 673., 673.

```

```

02821     };
02822
02823     static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824         2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825         2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826         2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827         2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828         2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829         2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,
02830         2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831         2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832         2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833         2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834     };
02835
02836     double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838     int idx;
02839
02840     /* Check wavenumber range... */
02841     if (nu < nua[0] || nu > nua[97])
02842         return 0;
02843
02844     /* Interpolate B and beta... */
02845     idx = locate_reg(nua, 98, nu);
02846     b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847     beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849     /* Compute absorption coefficient... */
02850     return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851         * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }
02853
02854 /*****
02855
02856 double ctmo2(
02857     double nu,
02858     double p,
02859     double t) {
02860
02861     static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862         .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863         1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864         2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865         4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866         3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867         2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868         1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869         .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870         .071, .064, 0.
02871     };
02872
02873     static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874         531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875         193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876         -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877         -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878         -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879         123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880         321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881         346., 322., 291., 290., 350., 371., 504., 504.
02882     };
02883
02884     static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885         1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886         1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887         1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888         1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,
02889         1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890         1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891         1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892         1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893         1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894         1800., 1805.
02895     };
02896
02897     double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899     int idx;
02900
02901     /* Check wavenumber range... */
02902     if (nu < nua[0] || nu > nua[89])
02903         return 0;
02904
02905     /* Interpolate B and beta... */
02906     idx = locate_reg(nua, 90, nu);
02907     b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);

```

```

02908     beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910     /* Compute absorption coefficient... */
02911     return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912         b;
02913 }
02914
02915 /*****
02916
02917 void copy_atm(
02918     ctl_t * ctl,
02919     atm_t * atm_dest,
02920     atm_t * atm_src,
02921     int init) {
02922
02923     int ig, ip, iw;
02924
02925     size_t s;
02926
02927     /* Data size... */
02928     s = (size_t) atm_src->np * sizeof(double);
02929
02930     /* Copy data... */
02931     atm_dest->np = atm_src->np;
02932     memcpy(atm_dest->time, atm_src->time, s);
02933     memcpy(atm_dest->z, atm_src->z, s);
02934     memcpy(atm_dest->lon, atm_src->lon, s);
02935     memcpy(atm_dest->lat, atm_src->lat, s);
02936     memcpy(atm_dest->p, atm_src->p, s);
02937     memcpy(atm_dest->t, atm_src->t, s);
02938     for (ig = 0; ig < ctl->ng; ig++)
02939         memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940     for (iw = 0; iw < ctl->nw; iw++)
02941         memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943     /* Initialize... */
02944     if (init)
02945         for (ip = 0; ip < atm_dest->np; ip++) {
02946             atm_dest->p[ip] = 0;
02947             atm_dest->t[ip] = 0;
02948             for (ig = 0; ig < ctl->ng; ig++)
02949                 atm_dest->q[ig][ip] = 0;
02950             for (iw = 0; iw < ctl->nw; iw++)
02951                 atm_dest->k[iw][ip] = 0;
02952         }
02953 }
02954
02955 /*****
02956
02957 void copy_obs(
02958     ctl_t * ctl,
02959     obs_t * obs_dest,
02960     obs_t * obs_src,
02961     int init) {
02962
02963     int id, ir;
02964
02965     size_t s;
02966
02967     /* Data size... */
02968     s = (size_t) obs_src->nr * sizeof(double);
02969
02970     /* Copy data... */
02971     obs_dest->nr = obs_src->nr;
02972     memcpy(obs_dest->time, obs_src->time, s);
02973     memcpy(obs_dest->obsz, obs_src->obsz, s);
02974     memcpy(obs_dest->obslon, obs_src->obslon, s);
02975     memcpy(obs_dest->obslat, obs_src->obslat, s);
02976     memcpy(obs_dest->vpz, obs_src->vpz, s);
02977     memcpy(obs_dest->vplon, obs_src->vplon, s);
02978     memcpy(obs_dest->vplat, obs_src->vplat, s);
02979     memcpy(obs_dest->tpz, obs_src->tpz, s);
02980     memcpy(obs_dest->tplon, obs_src->tplon, s);
02981     memcpy(obs_dest->tplat, obs_src->tplat, s);
02982     for (id = 0; id < ctl->nd; id++)
02983         memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984     for (id = 0; id < ctl->nd; id++)
02985         memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987     /* Initialize... */
02988     if (init)
02989         for (id = 0; id < ctl->nd; id++)
02990             for (ir = 0; ir < obs_dest->nr; ir++)
02991                 if (gsl_finite(obs_dest->rad[id][ir])) {
02992                     obs_dest->rad[id][ir] = 0;
02993                     obs_dest->tau[id][ir] = 0;
02994                 }

```

```

02995 }
02996
02997 /*****
02998
02999 int find_emitter(
03000     ctl_t * ctl,
03001     const char *emitter) {
03002
03003     int ig;
03004
03005     for (ig = 0; ig < ctl->ng; ig++)
03006         if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007             return ig;
03008
03009     return -1;
03010 }
03011
03012 /*****
03013
03014 void formod(
03015     ctl_t * ctl,
03016     atm_t * atm,
03017     obs_t * obs) {
03018
03019     int id, ir, *mask;
03020
03021     /* Allocate... */
03022     ALLOC(mask, int,
03023           ND * NR);
03024
03025     /* Save observation mask... */
03026     for (id = 0; id < ctl->nd; id++)
03027         for (ir = 0; ir < obs->nr; ir++)
03028             mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030     /* Hydrostatic equilibrium... */
03031     hydrostatic(ctl, atm);
03032
03033     /* Calculate pencil beams... */
03034     for (ir = 0; ir < obs->nr; ir++)
03035         formod_pencil(ctl, atm, obs, ir);
03036
03037     /* Apply field-of-view convolution... */
03038     formod_fov(ctl, obs);
03039
03040     /* Convert radiance to brightness temperature... */
03041     if (ctl->write_bbt)
03042         for (id = 0; id < ctl->nd; id++)
03043             for (ir = 0; ir < obs->nr; ir++)
03044                 obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046     /* Apply observation mask... */
03047     for (id = 0; id < ctl->nd; id++)
03048         for (ir = 0; ir < obs->nr; ir++)
03049             if (mask[id * NR + ir])
03050                 obs->rad[id][ir] = GSL_NAN;
03051
03052     /* Free... */
03053     free(mask);
03054 }
03055
03056 /*****
03057
03058 void formod_continua(
03059     ctl_t * ctl,
03060     los_t * los,
03061     int ip,
03062     double *beta) {
03063
03064     static int ig_co2 = -999, ig_h2o = -999;
03065
03066     int id;
03067
03068     /* Extinction... */
03069     for (id = 0; id < ctl->nd; id++)
03070         beta[id] = los->k[ctl->window[id]][ip];
03071
03072     /* CO2 continuum... */
03073     if (ctl->ctm_co2) {
03074         if (ig_co2 == -999)
03075             ig_co2 = find_emitter(ctl, "CO2");
03076         if (ig_co2 >= 0)
03077             for (id = 0; id < ctl->nd; id++)
03078                 beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                                   los->u[ig_co2][ip]) / los->ds[ip];
03080     }
03081

```

```

03082  /* H2O continuum... */
03083  if (ctl->ctm_h2o) {
03084      if (ig_h2o == -999)
03085          ig_h2o = find_emitter(ctl, "H2O");
03086      if (ig_h2o >= 0)
03087          for (id = 0; id < ctl->nd; id++)
03088              beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                               los->q[ig_h2o][ip],
03090                               los->u[ig_h2o][ip]) / los->ds[ip];
03091  }
03092
03093  /* N2 continuum... */
03094  if (ctl->ctm_n2)
03095      for (id = 0; id < ctl->nd; id++)
03096          beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098  /* O2 continuum... */
03099  if (ctl->ctm_o2)
03100      for (id = 0; id < ctl->nd; id++)
03101          beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }
03103
03104 /*****
03105 void formod_fov(
03106     ctl_t * ctl,
03107     obs_t * obs) {
03108
03109     static double dz[NSHAPE], w[NSHAPE];
03110
03111     static int init = 0, n;
03112
03113     obs_t *obs2;
03114
03115     double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03116
03117     int i, id, idx, ir, ir2, nz;
03118
03119     /* Do not take into account FOV... */
03120     if (ctl->fov[0] == '-')
03121         return;
03122
03123     /* Initialize FOV data... */
03124     if (!init) {
03125         init = 1;
03126         read_shape(ctl->fov, dz, w, &n);
03127     }
03128
03129     /* Allocate... */
03130     ALLOC(obs2, obs_t, 1);
03131
03132     /* Copy observation data... */
03133     copy_obs(ctl, obs2, obs, 0);
03134
03135     /* Loop over ray paths... */
03136     for (ir = 0; ir < obs->nr; ir++) {
03137
03138         /* Get radiance and transmittance profiles... */
03139         nz = 0;
03140         for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03141              ir2++)
03142             if (obs->time[ir2] == obs->time[ir]) {
03143                 z[nz] = obs2->vpz[ir2];
03144                 for (id = 0; id < ctl->nd; id++) {
03145                     rad[id][nz] = obs2->rad[id][ir2];
03146                     tau[id][nz] = obs2->tau[id][ir2];
03147                 }
03148                 nz++;
03149             }
03150         if (nz < 2)
03151             ERRMSG("Cannot apply FOV convolution!");
03152
03153         /* Convolute profiles with FOV... */
03154         wsum = 0;
03155         for (id = 0; id < ctl->nd; id++) {
03156             obs->rad[id][ir] = 0;
03157             obs->tau[id][ir] = 0;
03158         }
03159         for (i = 0; i < n; i++) {
03160             zfov = obs->vpz[ir] + dz[i];
03161             idx = locate_irr(z, nz, zfov);
03162             for (id = 0; id < ctl->nd; id++) {
03163                 obs->rad[id][ir] += w[i]
03164                     * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03165                 obs->tau[id][ir] += w[i]
03166                     * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03167             }
03168         }
03169     }

```

```

03169         wsum += w[i];
03170     }
03171     for (id = 0; id < ctl->nd; id++) {
03172         obs->rad[id][ir] /= wsum;
03173         obs->tau[id][ir] /= wsum;
03174     }
03175 }
03176
03177 /* Free... */
03178 free(obs2);
03179 }
03180
03181 /*****
03182
03183 void formod_pencil(
03184     ctl_t * ctl,
03185     atm_t * atm,
03186     obs_t * obs,
03187     int ir) {
03188
03189     static tbl_t *tbl;
03190
03191     static int init = 0;
03192
03193     los_t *los;
03194
03195     double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197     int id, ip;
03198
03199     /* Initialize look-up tables... */
03200     if (!init) {
03201         init = 1;
03202         ALLOC(tbl, tbl_t, 1);
03203         init_tbl(ctl, tbl);
03204     }
03205
03206     /* Allocate... */
03207     ALLOC(los, los_t, 1);
03208
03209     /* Initialize... */
03210     for (id = 0; id < ctl->nd; id++) {
03211         obs->rad[id][ir] = 0;
03212         obs->tau[id][ir] = 1;
03213     }
03214
03215     /* Raytracing... */
03216     raytrace(ctl, atm, obs, los, ir);
03217
03218     /* Loop over LOS points... */
03219     for (ip = 0; ip < los->np; ip++) {
03220
03221         /* Get trace gas transmittance... */
03222         intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224         /* Get continuum absorption... */
03225         formod_continua(ctl, los, ip, beta_ctm);
03226
03227         /* Compute Planck function... */
03228         formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230         /* Loop over channels... */
03231         for (id = 0; id < ctl->nd; id++)
03232             if (tau_gas[id] > 0) {
03233
03234                 /* Get segment emissivity... */
03235                 eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237                 /* Compute radiance... */
03238                 obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240                 /* Compute path transmittance... */
03241                 obs->tau[id][ir] *= (1 - eps);
03242             }
03243     }
03244
03245     /* Add surface... */
03246     if (los->tsurf > 0) {
03247         formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248         for (id = 0; id < ctl->nd; id++)
03249             obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250     }
03251
03252     /* Free... */
03253     free(los);
03254 }
03255

```



```

03256 /*****
03257
03258 void formod_srcfunc(
03259     ctl_t * ctl,
03260     tbl_t * tbl,
03261     double t,
03262     double *src) {
03263
03264     int id, it;
03265
03266     /* Determine index in temperature array... */
03267     it = locate_reg(tbl->st, TBLNS, t);
03268
03269     /* Interpolate Planck function value... */
03270     for (id = 0; id < ctl->nd; id++)
03271         src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                     tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }
03274
03275 /*****
03276
03277 void geo2cart(
03278     double z,
03279     double lon,
03280     double lat,
03281     double *x) {
03282
03283     double radius;
03284
03285     radius = z + RE;
03286     x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287     x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288     x[2] = radius * sin(lat / 180 * M_PI);
03289 }
03290
03291 /*****
03292
03293 void hydrostatic(
03294     ctl_t * ctl,
03295     atm_t * atm) {
03296
03297     static int ig_h2o = -999;
03298
03299     double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301     int i, ip, ipref = 0, ipt = 0;
03302
03303     /* Check reference height... */
03304     if (ctl->hyd < 0)
03305         return;
03306
03307     /* Determine emitter index of H2O... */
03308     if (ig_h2o == -999)
03309         ig_h2o = find_emitter(ctl, "H2O");
03310
03311     /* Find air parcel next to reference height... */
03312     for (ip = 0; ip < atm->np; ip++)
03313         if (fabs(atm->z[ip] - ctl->hyd) < dzmin) {
03314             dzmin = fabs(atm->z[ip] - ctl->hyd);
03315             ipref = ip;
03316         }
03317
03318     /* Upper part of profile... */
03319     for (ip = ipref + 1; ip < atm->np; ip++) {
03320         mean = 0;
03321         for (i = 0; i < ipt; i++) {
03322             if (ig_h2o >= 0)
03323                 e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                         ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03325             mean += (e * mmh2o + (1 - e) * mmair)
03326                 * G0 / RI
03327                 / LIN(0.0, atm->t[ip - 1], ipt - 1.0, atm->t[ip], (double) i) / ipt;
03328         }
03329
03330         /* Compute p(z,T)... */
03331         atm->p[ip] =
03332             exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333     }
03334
03335     /* Lower part of profile... */
03336     for (ip = ipref - 1; ip >= 0; ip--) {
03337         mean = 0;
03338         for (i = 0; i < ipt; i++) {
03339             if (ig_h2o >= 0)
03340                 e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                         ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03342             mean += (e * mmh2o + (1 - e) * mmair)

```

```

03343         * G0 / RI
03344         / LIN(0.0, atm->t[ip + 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03345     }
03346
03347     /* Compute p(z,T) ... */
03348     atm->p[ip] =
03349     exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350 }
03351 }
03352
03353 /*****
03354
03355 void idx2name(
03356     ctl_t * ctl,
03357     int idx,
03358     char *quantity) {
03359
03360     int ig, iw;
03361
03362     if (idx == IDXP)
03363         sprintf(quantity, "PRESSURE");
03364
03365     if (idx == IDXT)
03366         sprintf(quantity, "TEMPERATURE");
03367
03368     for (ig = 0; ig < ctl->ng; ig++)
03369         if (idx == IDXQ(ig))
03370             sprintf(quantity, "%s", ctl->emitter[ig]);
03371
03372     for (iw = 0; iw < ctl->nw; iw++)
03373         if (idx == IDXK(iw))
03374             sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03375 }
03376
03377 /*****
03378
03379 void init_tbl(
03380     ctl_t * ctl,
03381     tbl_t * tbl) {
03382
03383     FILE *in;
03384
03385     char filename[2 * LEN], line[LEN];
03386
03387     double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388     f[NSHAPE], fsum, nu[NSHAPE];
03389
03390     int i, id, ig, ip, it, n;
03391
03392     /* Loop over trace gases and channels... */
03393     for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
03395     press_old,temp,temp_old,u,u_old,id,ip,it)
03396         for (id = 0; id < ctl->nd; id++) {
03397
03398         /* Initialize... */
03399         tbl->np[ig][id] = -1;
03400         eps_old = -999;
03401         press_old = -999;
03402         temp_old = -999;
03403         u_old = -999;
03404
03405         /* Try to open file... */
03406         sprintf(filename, "%s_%.4f_%.s.tab",
03407             ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03408         if (!(in = fopen(filename, "r"))) {
03409             printf("Missing emissivity table: %s\n", filename);
03410             continue;
03411         }
03412         printf("Read emissivity table: %s\n", filename);
03413
03414         /* Read data... */
03415         while (fgets(line, LEN, in)) {
03416
03417             /* Parse line... */
03418             if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03419                 continue;
03420
03421             /* Determine pressure index... */
03422             if (press != press_old) {
03423                 press_old = press;
03424                 if ((tbl->np[ig][id]) >= TBLNP)
03425                     ERRMSG("Too many pressure levels!");
03426                 tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03427             }
03428
03429             /* Determine temperature index... */

```

```

03429     if (temp != temp_old) {
03430         temp_old = temp;
03431         if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03432             ERRMSG("Too many temperatures!");
03433         tbl->nu[ig][id][tbl->np[ig][id]]
03434             [tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03435     }
03436
03437     /* Determine column density index... */
03438     if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03439         [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03440         eps_old = eps;
03441         u_old = u;
03442         if ((++tbl->nu[ig][id][tbl->np[ig][id]]
03443             [tbl->nt[ig][id][tbl->np[ig][id]]] >= TBLNU) {
03444             tbl->nu[ig][id][tbl->np[ig][id]]
03445                 [tbl->nt[ig][id][tbl->np[ig][id]]]--;
03446             continue;
03447         }
03448     }
03449
03450     /* Store data... */
03451     tbl->p[ig][id][tbl->np[ig][id]] = press;
03452     tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03453         = temp;
03454     tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03455         [tbl->nu[ig][id][tbl->np[ig][id]]]
03456         [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) u;
03457     tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458         [tbl->nu[ig][id][tbl->np[ig][id]]]
03459         [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) eps;
03460 }
03461
03462 /* Increment counters... */
03463 tbl->np[ig][id]++;
03464 for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465     tbl->nt[ig][id][ip]++;
03466     for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467         tbl->nu[ig][id][ip][it]++;
03468 }
03469
03470 /* Close file... */
03471 fclose(in);
03472 }
03473
03474 /* Write info... */
03475 printf("Initialize source function table...\n");
03476
03477 /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479 for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488         /* Set temperature... */
03489         tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491         /* Integrate Planck function... */
03492         fsum = 0;
03493         tbl->sr[id][it] = 0;
03494         for (i = 0; i < n; i++) {
03495             fsum += f[i];
03496             tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497         }
03498         tbl->sr[id][it] /= fsum;
03499     }
03500 }
03501 }
03502
03503 /*****
03504
03505 void intpol_atm(
03506     ctl_t * ctl,
03507     atm_t * atm,
03508     double z,
03509     double *p,
03510     double *t,
03511     double *q,
03512     double *k) {
03513
03514     int ig, ip, iw;
03515

```

```

03516  /* Get array index... */
03517  ip = locate_irr(atm->z, atm->np, z);
03518
03519  /* Interpolate... */
03520  *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521  *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522  for (ig = 0; ig < ctl->ng; ig++)
03523      q[ig] =
03524          LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525  for (iw = 0; iw < ctl->nw; iw++)
03526      k[iw] =
03527          LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528 }
03529
03530 /*****
03531
03532 void intpol_tbl(
03533     ctl_t * ctl,
03534     tbl_t * tbl,
03535     los_t * los,
03536     int ip,
03537     double tau_path[NG][ND],
03538     double tau_seg[ND]) {
03539
03540     double eps, eps00, eps01, eps10, eps11, u;
03541
03542     int id, ig, ipr, it0, it1;
03543
03544     /* Initialize... */
03545     if (ip <= 0)
03546         for (ig = 0; ig < ctl->ng; ig++)
03547             for (id = 0; id < ctl->nd; id++)
03548                 tau_path[ig][id] = 1;
03549
03550     /* Loop over channels... */
03551     for (id = 0; id < ctl->nd; id++) {
03552
03553         /* Initialize... */
03554         tau_seg[id] = 1;
03555
03556         /* Loop over emitters... */
03557         for (ig = 0; ig < ctl->ng; ig++) {
03558
03559             /* Check size of table (pressure)... */
03560             if (tbl->np[ig][id] < 2)
03561                 eps = 0;
03562
03563             /* Check transmittance... */
03564             else if (tau_path[ig][id] < 1e-9)
03565                 eps = 1;
03566
03567             /* Interpolate... */
03568             else {
03569
03570                 /* Determine pressure and temperature indices... */
03571                 ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572                 it0 =
03573                     locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
03574 t[ip]);
03575                 it1 =
03576                     locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03577                             los->t[ip]);
03578
03579                 /* Check size of table (temperature and column density)... */
03580                 if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03581                     || tbl->nu[ig][id][ipr][it0] < 2
03582                     || tbl->nu[ig][id][ipr][it0 + 1] < 2
03583                     || tbl->nu[ig][id][ipr + 1][it1] < 2
03584                     || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03585                     eps = 0;
03586                 else {
03587
03588                     /* Get emissivities of extended path... */
03589                     u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590                     eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592                     u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593                     eps01 =
03594                         intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596                     u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597                     eps10 =
03598                         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600                     u =
03601                         intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);

```

```

03602         eps11 =
03603         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
u[ig][ip]);
03604
03605         /* Interpolate with respect to temperature... */
03606         eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03607         tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03608         eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03609         tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03610
03611         /* Interpolate with respect to pressure... */
03612         eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03613         tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03614
03615         /* Check emssivity range... */
03616         eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03617
03618         /* Determine segment emissivity... */
03619         eps = 1 - (1 - eps00) / tau_path[ig][id];
03620     }
03621 }
03622
03623 /* Get transmittance of extended path... */
03624 tau_path[ig][id] *= (1 - eps);
03625
03626 /* Get segment transmittance... */
03627 tau_seg[id] *= (1 - eps);
03628 }
03629 }
03630 }
03631
03632 /*****
03633
03634 double intpol_tbl_eps(
03635     tbl_t * tbl,
03636     int ig,
03637     int id,
03638     int ip,
03639     int it,
03640     double u) {
03641
03642     int idx;
03643
03644     /* Lower boundary... */
03645     if (u < tbl->u[ig][id][ip][it][0])
03646         return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647         u);
03648
03649     /* Upper boundary... */
03650     else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651         return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652         tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653         1e30, 1, u);
03654
03655     /* Interpolation... */
03656     else {
03657
03658         /* Get index... */
03659         idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661         /* Interpolate... */
03662         return
03663         LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664         tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665         u);
03666     }
03667 }
03668
03669 /*****
03670
03671 double intpol_tbl_u(
03672     tbl_t * tbl,
03673     int ig,
03674     int id,
03675     int ip,
03676     int it,
03677     double eps) {
03678
03679     int idx;
03680
03681     /* Lower boundary... */
03682     if (eps < tbl->eps[ig][id][ip][it][0])
03683         return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684         eps);
03685
03686     /* Upper boundary... */
03687     else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])

```

```

03688     return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689                tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690                1, 1e30, eps);
03691
03692     /* Interpolation... */
03693     else {
03694
03695         /* Get index... */
03696         idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698         /* Interpolate... */
03699         return
03700             LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701                tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702                eps);
03703     }
03704 }
03705
03706 /*****
03707
03708 void jsec2time(
03709     double jsec,
03710     int *year,
03711     int *mon,
03712     int *day,
03713     int *hour,
03714     int *min,
03715     int *sec,
03716     double *remain) {
03717
03718     struct tm t0, *t1;
03719
03720     time_t jsec0;
03721
03722     t0.tm_year = 100;
03723     t0.tm_mon = 0;
03724     t0.tm_mday = 1;
03725     t0.tm_hour = 0;
03726     t0.tm_min = 0;
03727     t0.tm_sec = 0;
03728
03729     jsec0 = (time_t) jsec + timegm(&t0);
03730     t1 = gmtime(&jsec0);
03731
03732     *year = t1->tm_year + 1900;
03733     *mon = t1->tm_mon + 1;
03734     *day = t1->tm_mday;
03735     *hour = t1->tm_hour;
03736     *min = t1->tm_min;
03737     *sec = t1->tm_sec;
03738     *remain = jsec - floor(jsec);
03739 }
03740
03741 /*****
03742
03743 void kernel(
03744     ctl_t *ctl,
03745     atm_t *atm,
03746     obs_t *obs,
03747     gsl_matrix *k) {
03748
03749     atm_t *atml;
03750     obs_t *obs1;
03751
03752     gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754     int *iqa, j;
03755
03756     double h;
03757
03758     size_t i, n, m;
03759
03760     /* Get sizes... */
03761     m = k->size1;
03762     n = k->size2;
03763
03764     /* Allocate... */
03765     x0 = gsl_vector_alloc(n);
03766     yy0 = gsl_vector_alloc(m);
03767     ALLOC(iqa, int,
03768           N);
03769
03770     /* Compute radiance for undisturbed atmospheric data... */
03771     formod(ctl, atm, obs);
03772
03773     /* Compose vectors... */
03774     atm2x(ctl, atm, x0, iqa, NULL);

```

```

03775     obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777     /* Initialize kernel matrix... */
03778     gsl_matrix_set_zero(k);
03779
03780     /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atm1,
03782     obs1)
03783     for (j = 0; j < (int) n; j++) {
03784
03785         /* Allocate... */
03786         x1 = gsl_vector_alloc(n);
03787         yy1 = gsl_vector_alloc(m);
03788         ALLOC(atm1, atm_t, 1);
03789         ALLOC(obs1, obs_t, 1);
03790
03791         /* Set perturbation size... */
03792         if (iqa[j] == IDXP)
03793             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03794         else if (iqa[j] == IDXT)
03795             h = 1;
03796         else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03797             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03798         else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03799             h = 1e-4;
03800         else
03801             ERRMSG("Cannot set perturbation size!");
03802
03803         /* Disturb state vector element... */
03804         gsl_vector_memcpy(x1, x0);
03805         gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03806         copy_atm(ctl, atm1, atm, 0);
03807         copy_obs(ctl, obs1, obs, 0);
03808         x2atm(ctl, x1, atm1);
03809
03810         /* Compute radiance for disturbed atmospheric data... */
03811         formod(ctl, atm1, obs1);
03812
03813         /* Compose measurement vector for disturbed radiance data... */
03814         obs2y(ctl, obs1, yy1, NULL, NULL);
03815
03816         /* Compute derivatives... */
03817         for (i = 0; i < m; i++)
03818             gsl_matrix_set(k, i, (size_t) j,
03819                 (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03820
03821         /* Free... */
03822         gsl_vector_free(x1);
03823         gsl_vector_free(yy1);
03824         free(atm1);
03825         free(obs1);
03826     }
03827
03828     /* Free... */
03829     gsl_vector_free(x0);
03830     gsl_vector_free(yy0);
03831     free(iqa);
03832 }
03833
03834 /*****
03835 int locate_irr(
03836     double *xx,
03837     int n,
03838     double x) {
03839
03840     int i, ilo, ihi;
03841
03842     ilo = 0;
03843     ihi = n - 1;
03844     i = (ihi + ilo) >> 1;
03845
03846     if (xx[i] < xx[i + 1])
03847         while (ihi > ilo + 1) {
03848             i = (ihi + ilo) >> 1;
03849             if (xx[i] > x)
03850                 ihi = i;
03851             else
03852                 ilo = i;
03853         } else
03854         while (ihi > ilo + 1) {
03855             i = (ihi + ilo) >> 1;
03856             if (xx[i] <= x)
03857                 ihi = i;
03858             else
03859                 ilo = i;
03860         }

```

```

03861
03862     return ilo;
03863 }
03864
03865 /*****
03866
03867 int locate_reg(
03868     double *xx,
03869     int n,
03870     double x) {
03871
03872     int i;
03873
03874     /* Calculate index... */
03875     i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877     /* Check range... */
03878     if (i < 0)
03879         i = 0;
03880     else if (i >= n - 2)
03881         i = n - 2;
03882
03883     return i;
03884 }
03885
03886 /*****
03887
03888 int locate_tbl(
03889     float *xx,
03890     int n,
03891     double x) {
03892
03893     int i, ilo, ihi;
03894
03895     ilo = 0;
03896     ihi = n - 1;
03897     i = (ihi + ilo) >> 1;
03898
03899     while (ihi > ilo + 1) {
03900         i = (ihi + ilo) >> 1;
03901         if (xx[i] > x)
03902             ihi = i;
03903         else
03904             ilo = i;
03905     }
03906
03907     return ilo;
03908 }
03909
03910 /*****
03911
03912 size_t obs2y(
03913     ctl_t * ctl,
03914     obs_t * obs,
03915     gsl_vector * y,
03916     int *ida,
03917     int *ira) {
03918
03919     int id, ir;
03920
03921     size_t m = 0;
03922
03923     /* Determine measurement vector... */
03924     for (ir = 0; ir < obs->nr; ir++)
03925         for (id = 0; id < ctl->nd; id++)
03926             if (gsl_finite(obs->rad[id][ir])) {
03927                 if (y != NULL)
03928                     gsl_vector_set(y, m, obs->rad[id][ir]);
03929                 if (ida != NULL)
03930                     ida[m] = id;
03931                 if (ira != NULL)
03932                     ira[m] = ir;
03933                 m++;
03934             }
03935
03936     return m;
03937 }
03938
03939 /*****
03940
03941 double planck(
03942     double t,
03943     double nu) {
03944
03945     return C1 * POW3(nu) / gsl_expm1(C2 * nu / t);
03946 }
03947

```



```

03948 /*****/
03949
03950 void raytrace(
03951     ctl_t * ctl,
03952     atm_t * atm,
03953     obs_t * obs,
03954     los_t * los,
03955     int ir) {
03956
03957     double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958         lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959         xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961     int i, ig, ip, iw, stop = 0;
03962
03963     /* Initialize... */
03964     los->np = 0;
03965     los->tsurf = -999;
03966     obs->tpz[ir] = obs->vpz[ir];
03967     obs->tplon[ir] = obs->vplon[ir];
03968     obs->tplat[ir] = obs->vplat[ir];
03969
03970     /* Get altitude range of atmospheric data... */
03971     gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973     /* Check observer altitude... */
03974     if (obs->obsz[ir] < zmin)
03975         ERRMSG("Observer below surface!");
03976
03977     /* Check view point altitude... */
03978     if (obs->vpz[ir] > zmax)
03979         return;
03980
03981     /* Determine Cartesian coordinates for observer and view point... */
03982     geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983     geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985     /* Determine initial tangent vector... */
03986     for (i = 0; i < 3; i++)
03987         ex0[i] = xvp[i] - xobs[i];
03988     norm = NORM(ex0);
03989     for (i = 0; i < 3; i++)
03990         ex0[i] /= norm;
03991
03992     /* Observer within atmosphere... */
03993     for (i = 0; i < 3; i++)
03994         x[i] = xobs[i];
03995
03996     /* Observer above atmosphere (search entry point)... */
03997     if (obs->obsz[ir] > zmax) {
03998         dmax = norm;
03999         while (fabs(dmin - dmax) > 0.001) {
04000             d = (dmax + dmin) / 2;
04001             for (i = 0; i < 3; i++)
04002                 x[i] = xobs[i] + d * ex0[i];
04003             cart2geo(x, &z, &lon, &lat);
04004             if (z <= zmax && z > zmax - 0.001)
04005                 break;
04006             if (z < zmax - 0.0005)
04007                 dmax = d;
04008             else
04009                 dmin = d;
04010         }
04011     }
04012
04013     /* Ray-tracing... */
04014     while (1) {
04015
04016         /* Set step length... */
04017         ds = ctl->rayds;
04018         if (ctl->raydz > 0) {
04019             norm = NORM(x);
04020             for (i = 0; i < 3; i++)
04021                 xh[i] = x[i] / norm;
04022             cosa = fabs(DOTP(ex0, xh));
04023             if (cosa != 0)
04024                 ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025         }
04026
04027         /* Determine geolocation... */
04028         cart2geo(x, &z, &lon, &lat);
04029
04030         /* Check if LOS hits the ground or has left atmosphere... */
04031         if (z < zmin || z > zmax) {
04032             stop = (z < zmin ? 2 : 1);
04033             frac =
04034                 ((z <

```

```

04035         zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                     1]);
04037     geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038             los->lat[los->np - 1], xh);
04039     for (i = 0; i < 3; i++)
04040         x[i] = xh[i] + frac * (x[i] - xh[i]);
04041     cart2geo(x, &z, &lon, &lat);
04042     los->ds[los->np - 1] = ds * frac;
04043     ds = 0;
04044 }
04045
04046 /* Interpolate atmospheric data... */
04047 intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049 /* Save data... */
04050 los->lon[los->np] = lon;
04051 los->lat[los->np] = lat;
04052 los->z[los->np] = z;
04053 los->p[los->np] = p;
04054 los->t[los->np] = t;
04055 for (ig = 0; ig < ctl->ng; ig++)
04056     los->q[ig][los->np] = q[ig];
04057 for (iw = 0; iw < ctl->nw; iw++)
04058     los->k[iw][los->np] = k[iw];
04059 los->ds[los->np] = ds;
04060
04061 /* Increment and check number of LOS points... */
04062 if ((++los->np) > NLOS)
04063     ERRMSG("Too many LOS points!");
04064
04065 /* Check stop flag... */
04066 if (stop) {
04067     los->tsurf = (stop == 2 ? t : -999);
04068     break;
04069 }
04070
04071 /* Determine refractivity... */
04072 if (ctl->refrac && z <= zrefrac)
04073     n = 1 + refractivity(p, t);
04074 else
04075     n = 1;
04076
04077 /* Construct new tangent vector (first term)... */
04078 for (i = 0; i < 3; i++)
04079     ex1[i] = ex0[i] * n;
04080
04081 /* Compute gradient of refractivity... */
04082 if (ctl->refrac && z <= zrefrac) {
04083     for (i = 0; i < 3; i++)
04084         xh[i] = x[i] + 0.5 * ds * ex0[i];
04085     cart2geo(xh, &z, &lon, &lat);
04086     intpol_atm(ctl, atm, z, &p, &t, q, k);
04087     n = refractivity(p, t);
04088     for (i = 0; i < 3; i++) {
04089         xh[i] += h;
04090         cart2geo(xh, &z, &lon, &lat);
04091         intpol_atm(ctl, atm, z, &p, &t, q, k);
04092         naux = refractivity(p, t);
04093         ng[i] = (naux - n) / h;
04094         xh[i] -= h;
04095     }
04096 } else
04097     for (i = 0; i < 3; i++)
04098         ng[i] = 0;
04099
04100 /* Construct new tangent vector (second term)... */
04101 for (i = 0; i < 3; i++)
04102     ex1[i] += ds * ng[i];
04103
04104 /* Normalize new tangent vector... */
04105 norm = NORM(ex1);
04106 for (i = 0; i < 3; i++)
04107     ex1[i] /= norm;
04108
04109 /* Determine next point of LOS... */
04110 for (i = 0; i < 3; i++)
04111     x[i] += 0.5 * ds * (ex0[i] + ex1[i]);
04112
04113 /* Copy tangent vector... */
04114 for (i = 0; i < 3; i++)
04115     ex0[i] = ex1[i];
04116 }
04117
04118 /* Get tangent point (to be done before changing segment lengths!)... */
04119 tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
04120             tplat[ir]);

```

```

04121  /* Change segment lengths according to trapezoid rule... */
04122  for (ip = los->np - 1; ip >= 1; ip--)
04123      los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04124  los->ds[0] *= 0.5;
04125
04126  /* Compute column density... */
04127  for (ip = 0; ip < los->np; ip++)
04128      for (ig = 0; ig < ctl->ng; ig++)
04129          los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04130          / (KB * los->t[ip]) * los->ds[ip];
04131  }
04132
04133  /*****
04134
04135  void read_atm(
04136      const char *dirname,
04137      const char *filename,
04138      ctl_t * ctl,
04139      atm_t * atm) {
04140
04141      FILE *in;
04142
04143      char file[LEN], line[LEN], *tok;
04144
04145      int ig, iw;
04146
04147      /* Init... */
04148      atm->np = 0;
04149
04150      /* Set filename... */
04151      if (dirname != NULL)
04152          sprintf(file, "%s/%s", dirname, filename);
04153      else
04154          sprintf(file, "%s", filename);
04155
04156      /* Write info... */
04157      printf("Read atmospheric data: %s\n", file);
04158
04159      /* Open file... */
04160      if (!(in = fopen(file, "r")))
04161          ERRMSG("Cannot open file!");
04162
04163      /* Read line... */
04164      while (fgets(line, LEN, in)) {
04165
04166          /* Read data... */
04167          TOK(line, tok, "%lg", atm->time[atm->np]);
04168          TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169          TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170          TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171          TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172          TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173          for (ig = 0; ig < ctl->ng; ig++)
04174              TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175          for (iw = 0; iw < ctl->nw; iw++)
04176              TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178          /* Increment data point counter... */
04179          if ((++atm->np) > NP)
04180              ERRMSG("Too many data points!");
04181      }
04182
04183      /* Close file... */
04184      fclose(in);
04185
04186      /* Check number of points... */
04187      if (atm->np < 1)
04188          ERRMSG("Could not read any data!");
04189  }
04190
04191  /*****
04192
04193  void read_ctl(
04194      int argc,
04195      char *argv[],
04196      ctl_t * ctl) {
04197
04198      int id, ig, iw;
04199
04200      /* Write info... */
04201      printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202            "(executable: %s | compiled: %s, %s)\n\n",
04203            argv[0], __DATE__, __TIME__);
04204
04205      /* Emitters... */
04206      ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207      if (ctl->ng < 0 || ctl->ng > NG)

```

```

04208     ERRMSG("Set 0 <= NG <= MAX!");
04209     for (ig = 0; ig < ctl->ng; ig++)
04210         scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212     /* Radiance channels... */
04213     ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214     if (ctl->nd < 0 || ctl->nd > ND)
04215         ERRMSG("Set 0 <= ND <= MAX!");
04216     for (id = 0; id < ctl->nd; id++)
04217         ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219     /* Spectral windows... */
04220     ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221     if (ctl->nw < 0 || ctl->nw > NW)
04222         ERRMSG("Set 0 <= NW <= MAX!");
04223     for (id = 0; id < ctl->nd; id++)
04224         ctl->>window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226     /* Emissivity look-up tables... */
04227     scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229     /* Hydrostatic equilibrium... */
04230     ctl->hydZ = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232     /* Continua... */
04233     ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234     ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235     ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236     ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238     /* Ray-tracing... */
04239     ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240     ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241     ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243     /* Field of view... */
04244     scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246     /* Retrieval interface... */
04247     ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248     ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249     ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250     ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251     for (ig = 0; ig < ctl->ng; ig++) {
04252         ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253         ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254     }
04255     for (iw = 0; iw < ctl->nw; iw++) {
04256         ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257         ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258     }
04259
04260     /* Output flags... */
04261     ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262     ctl->write_matrix =
04263         (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }
04265
04266 /*****
04267
04268 void read_matrix(
04269     const char *dirname,
04270     const char *filename,
04271     gsl_matrix * matrix) {
04272
04273     FILE *in;
04274
04275     char dum[LEN], file[LEN], line[LEN];
04276
04277     double value;
04278
04279     int i, j;
04280
04281     /* Set filename... */
04282     if (dirname != NULL)
04283         sprintf(file, "%s/%s", dirname, filename);
04284     else
04285         sprintf(file, "%s", filename);
04286
04287     /* Write info... */
04288     printf("Read matrix: %s\n", file);
04289
04290     /* Open file... */
04291     if (!(in = fopen(file, "r")))
04292         ERRMSG("Cannot open file!");
04293
04294     /* Read data... */

```

```

04295     gsl_matrix_set_zero(matrix);
04296     while (fgets(line, LEN, in))
04297         if (sscanf(line, "%d %s %s %s %s %d %s %s %s %s %s %lg",
04298             &i, dum, dum, dum, dum, dum,
04299             &j, dum, dum, dum, dum, dum, &value) == 13)
04300         gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302     /* Close file... */
04303     fclose(in);
04304 }
04305
04306 /*****
04307
04308 void read_obs(
04309     const char *dirname,
04310     const char *filename,
04311     ctl_t * ctl,
04312     obs_t * obs) {
04313
04314     FILE *in;
04315
04316     char file[LEN], line[LEN], *tok;
04317
04318     int id;
04319
04320     /* Init... */
04321     obs->nr = 0;
04322
04323     /* Set filename... */
04324     if (dirname != NULL)
04325         sprintf(file, "%s/%s", dirname, filename);
04326     else
04327         sprintf(file, "%s", filename);
04328
04329     /* Write info... */
04330     printf("Read observation data: %s\n", file);
04331
04332     /* Open file... */
04333     if (!(in = fopen(file, "r")))
04334         ERRMSG("Cannot open file!");
04335
04336     /* Read line... */
04337     while (fgets(line, LEN, in)) {
04338
04339         /* Read data... */
04340         TOK(line, tok, "%lg", obs->time[obs->nr]);
04341         TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342         TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343         TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344         TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345         TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346         TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347         TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348         TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349         TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350         for (id = 0; id < ctl->nd; id++)
04351             TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352         for (id = 0; id < ctl->nd; id++)
04353             TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355         /* Increment counter... */
04356         if ((++obs->nr) > NR)
04357             ERRMSG("Too many rays!");
04358     }
04359
04360     /* Close file... */
04361     fclose(in);
04362
04363     /* Check number of points... */
04364     if (obs->nr < 1)
04365         ERRMSG("Could not read any data!");
04366 }
04367
04368 /*****
04369
04370 void read_shape(
04371     const char *filename,
04372     double *x,
04373     double *y,
04374     int *n) {
04375
04376     FILE *in;
04377
04378     char line[LEN];
04379
04380     /* Write info... */
04381     printf("Read shape function: %s\n", filename);

```

```

04382
04383 /* Open file... */
04384 if (!(in = fopen(filename, "r")))
04385     ERRMSG("Cannot open file!");
04386
04387 /* Read data... */
04388 *n = 0;
04389 while (fgets(line, LEN, in))
04390     if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391         if ((++(*n)) > NSHAPE)
04392             ERRMSG("Too many data points!");
04393
04394 /* Check number of points... */
04395 if (*n < 1)
04396     ERRMSG("Could not read any data!");
04397
04398 /* Close file... */
04399 fclose(in);
04400 }
04401
04402 /*****
04403
04404 double refractivity(
04405     double p,
04406     double t) {
04407
04408     /* Refractivity of air at 4 to 15 micron... */
04409     return 7.753e-05 * p / t;
04410 }
04411
04412 *****/
04413
04414 double scan_ctl(
04415     int argc,
04416     char *argv[],
04417     const char *varname,
04418     int arridx,
04419     const char *defvalue,
04420     char *value) {
04421
04422     FILE *in = NULL;
04423
04424     char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425         msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427     int contain = 0, i;
04428
04429     /* Open file... */
04430     if (argv[1][0] != '-')
04431         if (!(in = fopen(argv[1], "r")))
04432             ERRMSG("Cannot open file!");
04433
04434     /* Set full variable name... */
04435     if (arridx >= 0) {
04436         sprintf(fullname1, "%s[%d]", varname, arridx);
04437         sprintf(fullname2, "%s[*]", varname);
04438     } else {
04439         sprintf(fullname1, "%s", varname);
04440         sprintf(fullname2, "%s", varname);
04441     }
04442
04443     /* Read data... */
04444     if (in != NULL)
04445         while (fgets(line, LEN, in))
04446             if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447                 if (strcasecmp(rvarname, fullname1) == 0 ||
04448                     strcasecmp(rvarname, fullname2) == 0) {
04449                     contain = 1;
04450                     break;
04451                 }
04452     for (i = 1; i < argc - 1; i++)
04453         if (strcasecmp(argv[i], fullname1) == 0 ||
04454             strcasecmp(argv[i], fullname2) == 0) {
04455             sprintf(rval, "%s", argv[i + 1]);
04456             contain = 1;
04457             break;
04458         }
04459
04460     /* Close file... */
04461     if (in != NULL)
04462         fclose(in);
04463
04464     /* Check for missing variables... */
04465     if (!contain) {
04466         if (strlen(defvalue) > 0)
04467             sprintf(rval, "%s", defvalue);
04468         else {

```

```

04469     sprintf(msg, "Missing variable %s!\n", fullname1);
04470     ERRMSG(msg);
04471 }
04472 }
04473
04474 /* Write info... */
04475 printf("%s = %s\n", fullname1, rval);
04476
04477 /* Return values... */
04478 if (value != NULL)
04479     sprintf(value, "%s", rval);
04480 return atof(rval);
04481 }
04482
04483 /*****
04484
04485 void tangent_point(
04486     los_t * los,
04487     double *tpz,
04488     double *tplon,
04489     double *tplat) {
04490
04491     double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493     size_t i, ip;
04494
04495     /* Find minimum altitude... */
04496     ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498     /* Nadir or zenith... */
04499     if (ip <= 0 || ip >= (size_t) los->np - 1) {
04500         *tpz = los->z[los->np - 1];
04501         *tplon = los->lon[los->np - 1];
04502         *tplat = los->lat[los->np - 1];
04503     }
04504
04505     /* Limb... */
04506     else {
04507
04508         /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509         yy0 = los->z[ip - 1];
04510         yy1 = los->z[ip];
04511         yy2 = los->z[ip + 1];
04512         x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513         x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514         a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515         b = -(yy0 - yy1) / x1 - a * x1;
04516         c = yy0;
04517
04518         /* Get tangent point location... */
04519         x = -b / (2 * a);
04520         *tpz = a * x * x + b * x + c;
04521         geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522         geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523         for (i = 0; i < 3; i++)
04524             v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525         cart2geo(v, &dummy, tplon, tplat);
04526     }
04527 }
04528
04529 /*****
04530
04531 void time2jsec(
04532     int year,
04533     int mon,
04534     int day,
04535     int hour,
04536     int min,
04537     int sec,
04538     double remain,
04539     double *jsec) {
04540
04541     struct tm t0, t1;
04542
04543     t0.tm_year = 100;
04544     t0.tm_mon = 0;
04545     t0.tm_mday = 1;
04546     t0.tm_hour = 0;
04547     t0.tm_min = 0;
04548     t0.tm_sec = 0;
04549
04550     t1.tm_year = year - 1900;
04551     t1.tm_mon = mon - 1;
04552     t1.tm_mday = day;
04553     t1.tm_hour = hour;
04554     t1.tm_min = min;
04555     t1.tm_sec = sec;

```

```

04556
04557     *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }
04559
04560 /*****
04561
04562 void timer(
04563     const char *name,
04564     const char *file,
04565     const char *func,
04566     int line,
04567     int mode) {
04568
04569     static double w0[10];
04570
04571     static int l0[10], nt;
04572
04573     /* Start new timer... */
04574     if (mode == 1) {
04575         w0[nt] = omp_get_wtime();
04576         l0[nt] = line;
04577         if ((++nt) >= 10)
04578             ERRMSG("Too many timers!");
04579     }
04580
04581     /* Write elapsed time... */
04582     else {
04583
04584         /* Check timer index... */
04585         if (nt - 1 < 0)
04586             ERRMSG("Coding error!");
04587
04588         /* Write elapsed time... */
04589         printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590             name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591     }
04592
04593     /* Stop timer... */
04594     if (mode == 3)
04595         nt--;
04596 }
04597
04598 /*****
04599
04600 void write_atm(
04601     const char *dirname,
04602     const char *filename,
04603     ctl_t *ctl,
04604     atm_t *atm) {
04605
04606     FILE *out;
04607
04608     char file[LEN];
04609
04610     int ig, ip, iw, n = 6;
04611
04612     /* Set filename... */
04613     if (dirname != NULL)
04614         sprintf(file, "%s/%s", dirname, filename);
04615     else
04616         sprintf(file, "%s", filename);
04617
04618     /* Write info... */
04619     printf("Write atmospheric data: %s\n", file);
04620
04621     /* Create file... */
04622     if (!(out = fopen(file, "w")))
04623         ERRMSG("Cannot create file!");
04624
04625     /* Write header... */
04626     fprintf(out,
04627         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628         "# $2 = altitude [km]\n"
04629         "# $3 = longitude [deg]\n"
04630         "# $4 = latitude [deg]\n"
04631         "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632     for (ig = 0; ig < ctl->ng; ig++)
04633         fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634     for (iw = 0; iw < ctl->nw; iw++)
04635         fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636
04637     /* Write data... */
04638     for (ip = 0; ip < atm->np; ip++) {
04639         if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640             || atm->lon[ip] != atm->lon[ip - 1])
04641             fprintf(out, "\n");
04642         fprintf(out, "%.2f %g %g %g %g %g", atm->time[ip], atm->z[ip],

```



```

04643         atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644     for (ig = 0; ig < ctl->ng; ig++)
04645         fprintf(out, " %g", atm->q[ig][ip]);
04646     for (iw = 0; iw < ctl->nw; iw++)
04647         fprintf(out, " %g", atm->k[iw][ip]);
04648     fprintf(out, "\n");
04649 }
04650
04651 /* Close file... */
04652 fclose(out);
04653 }
04654
04655 /*****
04656
04657 void write_matrix(
04658     const char *dirname,
04659     const char *filename,
04660     ctl_t *ctl,
04661     gsl_matrix *matrix,
04662     atm_t *atm,
04663     obs_t *obs,
04664     const char *row_space,
04665     const char *col_space,
04666     const char *sort) {
04667
04668     FILE *out;
04669
04670     char file[LEN], quantity[LEN];
04671
04672     int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674     size_t i, j, nc, nr;
04675
04676     /* Check output flag... */
04677     if (!ctl->write_matrix)
04678         return;
04679
04680     /* Allocate... */
04681     ALLOC(cida, int, M);
04682     ALLOC(ciqa, int,
04683           N);
04684     ALLOC(cipa, int,
04685           N);
04686     ALLOC(cira, int,
04687           M);
04688     ALLOC(rida, int,
04689           M);
04690     ALLOC(riqa, int,
04691           N);
04692     ALLOC(ripa, int,
04693           N);
04694     ALLOC(rira, int,
04695           M);
04696
04697     /* Set filename... */
04698     if (dirname != NULL)
04699         sprintf(file, "%s/%s", dirname, filename);
04700     else
04701         sprintf(file, "%s", filename);
04702
04703     /* Write info... */
04704     printf("Write matrix: %s\n", file);
04705
04706     /* Create file... */
04707     if (!(out = fopen(file, "w")))
04708         ERRMSG("Cannot create file!");
04709
04710     /* Write header (row space)... */
04711     if (row_space[0] == 'y') {
04712
04713         fprintf(out,
04714             "# $1 = Row: index (measurement space)\n"
04715             "# $2 = Row: channel wavenumber [cm^-1]\n"
04716             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04717             "# $4 = Row: view point altitude [km]\n"
04718             "# $5 = Row: view point longitude [deg]\n"
04719             "# $6 = Row: view point latitude [deg]\n");
04720
04721         /* Get number of rows... */
04722         nr = obs2y(ctl, obs, NULL, rida, rira);
04723     } else {
04724
04725         fprintf(out,
04726             "# $1 = Row: index (state space)\n"
04727             "# $2 = Row: name of quantity\n"
04728             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"

```

```

04730         "# $4 = Row: altitude [km]\n"
04731         "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733     /* Get number of rows... */
04734     nr = atm2x(ctl, atm, NULL, rida, ripa);
04735 }
04736
04737 /* Write header (column space)... */
04738 if (colspace[0] == 'y') {
04739     fprintf(out,
04740         "# $7 = Col: index (measurement space)\n"
04741         "# $8 = Col: channel wavenumber [cm^-1]\n"
04742         "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04743         "# $10 = Col: view point altitude [km]\n"
04744         "# $11 = Col: view point longitude [deg]\n"
04745         "# $12 = Col: view point latitude [deg]\n");
04746
04747     /* Get number of columns... */
04748     nc = obs2y(ctl, obs, NULL, cida, cira);
04749 } else {
04750     fprintf(out,
04751         "# $7 = Col: index (state space)\n"
04752         "# $8 = Col: name of quantity\n"
04753         "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04754         "# $10 = Col: altitude [km]\n"
04755         "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04756
04757     /* Get number of columns... */
04758     nc = atm2x(ctl, atm, NULL, cipa, cipa);
04759 }
04760
04761 /* Write header entry... */
04762 fprintf(out, "# $13 = Matrix element\n\n");
04763
04764 /* Write matrix data... */
04765 i = j = 0;
04766 while (i < nr && j < nc) {
04767     /* Write info about the row... */
04768     if (rowspan[0] == 'y')
04769         fprintf(out, "%d %g %.2f %g %g %g",
04770             (int) i, ctl->nu[rida[i]],
04771             obs->time[rira[i]], obs->vpz[rira[i]],
04772             obs->vplon[rira[i]], obs->vplat[rira[i]]);
04773     else {
04774         idx2name(ctl, rida[i], quantity);
04775         fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04776             atm->time[rida[i]], atm->z[rida[i]],
04777             atm->lon[rida[i]], atm->lat[rida[i]]);
04778     }
04779
04780     /* Write info about the column... */
04781     if (colspace[0] == 'y')
04782         fprintf(out, " %d %g %.2f %g %g %g",
04783             (int) j, ctl->nu[cida[j]],
04784             obs->time[cira[j]], obs->vpz[cira[j]],
04785             obs->vplon[cira[j]], obs->vplat[cira[j]]);
04786     else {
04787         idx2name(ctl, cida[j], quantity);
04788         fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04789             atm->time[cipa[j]], atm->z[cipa[j]],
04790             atm->lon[cipa[j]], atm->lat[cipa[j]]);
04791     }
04792
04793     /* Write matrix entry... */
04794     fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04795
04796     /* Set matrix indices... */
04797     if (sort[0] == 'r') {
04798         j++;
04799         if (j >= nc) {
04800             j = 0;
04801             i++;
04802             fprintf(out, "\n");
04803         }
04804     } else {
04805         i++;
04806         if (i >= nr) {
04807             i = 0;
04808             j++;
04809             fprintf(out, "\n");
04810         }
04811     }
04812 }
04813 }
04814 }
04815 }
04816 }

```

```

04817
04818  /* Close file... */
04819  fclose(out);
04820
04821  /* Free... */
04822  free(cida);
04823  free(ciga);
04824  free(cipa);
04825  free(cira);
04826  free(rida);
04827  free(riqa);
04828  free(ripa);
04829  free(rira);
04830 }
04831
04832 /*****
04833
04834 void write_obs(
04835     const char *dirname,
04836     const char *filename,
04837     ctl_t * ctl,
04838     obs_t * obs) {
04839
04840     FILE *out;
04841
04842     char file[LEN];
04843
04844     int id, ir, n = 10;
04845
04846     /* Set filename... */
04847     if (dirname != NULL)
04848         sprintf(file, "%s/%s", dirname, filename);
04849     else
04850         sprintf(file, "%s", filename);
04851
04852     /* Write info... */
04853     printf("Write observation data: %s\n", file);
04854
04855     /* Create file... */
04856     if (!(out = fopen(file, "w")))
04857         ERRMSG("Cannot create file!");
04858
04859     /* Write header... */
04860     fprintf(out,
04861         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862         "# $2 = observer altitude [km]\n"
04863         "# $3 = observer longitude [deg]\n"
04864         "# $4 = observer latitude [deg]\n"
04865         "# $5 = view point altitude [km]\n"
04866         "# $6 = view point longitude [deg]\n"
04867         "# $7 = view point latitude [deg]\n"
04868         "# $8 = tangent point altitude [km]\n"
04869         "# $9 = tangent point longitude [deg]\n"
04870         "# $10 = tangent point latitude [deg]\n");
04871     for (id = 0; id < ctl->nd; id++)
04872         fprintf(out, "# $%d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873             ++n, ctl->nu[id]);
04874     for (id = 0; id < ctl->nd; id++)
04875         fprintf(out, "# $%d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877     /* Write data... */
04878     for (ir = 0; ir < obs->nr; ir++) {
04879         if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880             fprintf(out, "\n");
04881         fprintf(out, "%.2f %g %g %g %g %g %g %g %g", obs->time[ir],
04882             obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883             obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884             obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885         for (id = 0; id < ctl->nd; id++)
04886             fprintf(out, " %g", obs->rad[id][ir]);
04887         for (id = 0; id < ctl->nd; id++)
04888             fprintf(out, " %g", obs->tau[id][ir]);
04889         fprintf(out, "\n");
04890     }
04891
04892     /* Close file... */
04893     fclose(out);
04894 }
04895
04896 /*****
04897
04898 void x2atm(
04899     ctl_t * ctl,
04900     gsl_vector * x,
04901     atm_t * atm) {
04902
04903     int ig, iw;

```

```

04904
04905     size_t n = 0;
04906
04907     /* Set pressure... */
04908     x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
04909 p, x, &n);
04909
04910     /* Set temperature... */
04911     x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
04912 t, x, &n);
04912
04913     /* Set volume mixing ratio... */
04914     for (ig = 0; ig < ctl->ng; ig++)
04915         x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916 atm->q[ig], x, &n);
04917
04918     /* Set extinction... */
04919     for (iw = 0; iw < ctl->nw; iw++)
04920         x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921 atm->k[iw], x, &n);
04922 }
04923
04924 /*****
04925
04926 void x2atm_help(
04927     atm_t * atm,
04928     double zmin,
04929     double zmax,
04930     double *value,
04931     gsl_vector * x,
04932     size_t * n) {
04933
04934     int ip;
04935
04936     /* Extract state vector elements... */
04937     for (ip = 0; ip < atm->np; ip++)
04938         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939             value[ip] = gsl_vector_get(x, *n);
04940             (*n)++;
04941         }
04942 }
04943
04944 /*****
04945
04946 void y2obs(
04947     ctl_t * ctl,
04948     gsl_vector * y,
04949     obs_t * obs) {
04950
04951     int id, ir;
04952
04953     size_t m = 0;
04954
04955     /* Decompose measurement vector... */
04956     for (ir = 0; ir < obs->nr; ir++)
04957         for (id = 0; id < ctl->nd; id++)
04958             if (gsl_finite(obs->rad[id][ir])) {
04959                 obs->rad[id][ir] = gsl_vector_get(y, m);
04960                 m++;
04961             }
04962 }

```

## 5.15 jurassic.h File Reference

JURASSIC library declarations.

### Data Structures

- struct [atm\\_t](#)  
*Atmospheric data.*
- struct [ctl\\_t](#)  
*Forward model control parameters.*
- struct [los\\_t](#)  
*Line-of-sight data.*

- struct [obs\\_t](#)  
*Observation geometry and radiance data.*
- struct [tbl\\_t](#)  
*Emissivity look-up tables.*

## Functions

- `size_t atm2x (ctl_t *ctl, atm_t *atm, gsl_vector *x, int *iqa, int *ipa)`  
*Compose state vector or parameter vector.*
- `void atm2x_help (atm_t *atm, double zmin, double zmax, double *value, int val_iqa, gsl_vector *x, int *iqa, int *ipa, size_t *n)`  
*Add elements to state vector.*
- `double brightness (double rad, double nu)`  
*Compute brightness temperature.*
- `void cart2geo (double *x, double *z, double *lon, double *lat)`  
*Convert Cartesian coordinates to geolocation.*
- `void climatology (ctl_t *ctl, atm_t *atm_mean)`  
*Interpolate climatological data.*
- `double ctmc02 (double nu, double p, double t, double u)`  
*Compute carbon dioxide continuum (optical depth).*
- `double ctmh2o (double nu, double p, double t, double q, double u)`  
*Compute water vapor continuum (optical depth).*
- `double ctmn2 (double nu, double p, double t)`  
*Compute nitrogen continuum (absorption coefficient).*
- `double ctmo2 (double nu, double p, double t)`  
*Compute oxygen continuum (absorption coefficient).*
- `void copy_atm (ctl_t *ctl, atm_t *atm_dest, atm_t *atm_src, int init)`  
*Copy and initialize atmospheric data.*
- `void copy_obs (ctl_t *ctl, obs_t *obs_dest, obs_t *obs_src, int init)`  
*Copy and initialize observation data.*
- `int find_emitter (ctl_t *ctl, const char *emitter)`  
*Find index of an emitter.*
- `void formod (ctl_t *ctl, atm_t *atm, obs_t *obs)`  
*Determine ray paths and compute radiative transfer.*
- `void formod_continua (ctl_t *ctl, los_t *los, int ip, double *beta)`  
*Compute absorption coefficient of continua.*
- `void formod_fov (ctl_t *ctl, obs_t *obs)`  
*Apply field of view convolution.*
- `void formod_pencil (ctl_t *ctl, atm_t *atm, obs_t *obs, int ir)`  
*Compute radiative transfer for a pencil beam.*
- `void formod_srcfunc (ctl_t *ctl, tbl_t *tbl, double t, double *src)`  
*Compute Planck source function.*
- `void geo2cart (double z, double lon, double lat, double *x)`  
*Convert geolocation to Cartesian coordinates.*
- `void hydrostatic (ctl_t *ctl, atm_t *atm)`  
*Set hydrostatic equilibrium.*
- `void idx2name (ctl_t *ctl, int idx, char *quantity)`  
*Determine name of state vector quantity for given index.*
- `void init_tbl (ctl_t *ctl, tbl_t *tbl)`  
*Initialize look-up tables.*

- void `intpol_atm` (`ctl_t` \*ctl, `atm_t` \*atm, double z, double \*p, double \*t, double \*q, double \*k)  
*Interpolate atmospheric data.*
- void `intpol_tbl` (`ctl_t` \*ctl, `tbl_t` \*tbl, `los_t` \*los, int ip, double tau\_path[NG][ND], double tau\_seg[ND])  
*Get transmittance from look-up tables.*
- double `intpol_tbl_eps` (`tbl_t` \*tbl, int ig, int id, int ip, int it, double u)  
*Interpolate emissivity from look-up tables.*
- double `intpol_tbl_u` (`tbl_t` \*tbl, int ig, int id, int ip, int it, double eps)  
*Interpolate column density from look-up tables.*
- void `jsec2time` (double jsec, int \*year, int \*mon, int \*day, int \*hour, int \*min, int \*sec, double \*remain)  
*Convert seconds to date.*
- void `kernel` (`ctl_t` \*ctl, `atm_t` \*atm, `obs_t` \*obs, gsl\_matrix \*k)  
*Compute Jacobians.*
- int `locate_irr` (double \*xx, int n, double x)  
*Find array index for irregular grid.*
- int `locate_reg` (double \*xx, int n, double x)  
*Find array index for regular grid.*
- int `locate_tbl` (float \*xx, int n, double x)  
*Find array index in float array.*
- size\_t `obs2y` (`ctl_t` \*ctl, `obs_t` \*obs, gsl\_vector \*y, int \*ida, int \*ira)  
*Compose measurement vector.*
- double `planck` (double t, double nu)  
*Compute Planck function.*
- void `raytrace` (`ctl_t` \*ctl, `atm_t` \*atm, `obs_t` \*obs, `los_t` \*los, int ir)  
*Do ray-tracing to determine LOS.*
- void `read_atm` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `atm_t` \*atm)  
*Read atmospheric data.*
- void `read_ctl` (int argc, char \*argv[], `ctl_t` \*ctl)  
*Read forward model control parameters.*
- void `read_matrix` (const char \*dirname, const char \*filename, gsl\_matrix \*matrix)  
*Read matrix.*
- void `read_obs` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `obs_t` \*obs)  
*Read observation data.*
- void `read_shape` (const char \*filename, double \*x, double \*y, int \*n)  
*Read shape function.*
- double `refractivity` (double p, double t)  
*Compute refractivity (return value is n - 1).*
- double `scan_ctl` (int argc, char \*argv[], const char \*varname, int arridx, const char \*defvalue, char \*value)  
*Search control parameter file for variable entry.*
- void `tangent_point` (`los_t` \*los, double \*tpz, double \*tplon, double \*tplat)  
*Find tangent point of a given LOS.*
- void `time2jsec` (int year, int mon, int day, int hour, int min, int sec, double remain, double \*jsec)  
*Convert date to seconds.*
- void `timer` (const char \*name, const char \*file, const char \*func, int line, int mode)  
*Measure wall-clock time.*
- void `write_atm` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `atm_t` \*atm)  
*Write atmospheric data.*
- void `write_matrix` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, gsl\_matrix \*matrix, `atm_t` \*atm, `obs_t` \*obs, const char \*rowsep, const char \*colsep, const char \*sort)  
*Write matrix.*
- void `write_obs` (const char \*dirname, const char \*filename, `ctl_t` \*ctl, `obs_t` \*obs)  
*Write observation data.*

- void `x2atm` (`ctl_t` \*ctl, `gsl_vector` \*x, `atm_t` \*atm)  
*Decompose parameter vector or state vector.*
- void `x2atm_help` (`atm_t` \*atm, double zmin, double zmax, double \*value, `gsl_vector` \*x, `size_t` \*n)  
*Extract elements from state vector.*
- void `y2obs` (`ctl_t` \*ctl, `gsl_vector` \*y, `obs_t` \*obs)  
*Decompose measurement vector.*

### 5.15.1 Detailed Description

JURASSIC library declarations.

Definition in file [jurassic.h](#).

### 5.15.2 Function Documentation

#### 5.15.2.1 `size_t atm2x ( ctl_t *ctl, atm_t *atm, gsl_vector *x, int *iqa, int *ipa )`

Compose state vector or parameter vector.

Definition at line 29 of file [jurassic.c](#).

```

00034         {
00035
00036     int ig, iw;
00037
00038     size_t n = 0;
00039
00040     /* Add pressure... */
00041     atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042               atm->p, IDXP, x, iqa, ipa, &n);
00043
00044     /* Add temperature... */
00045     atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046               atm->t, IDXT, x, iqa, ipa, &n);
00047
00048     /* Add volume mixing ratios... */
00049     for (ig = 0; ig < ctl->ng; ig++)
00050         atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                   atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053     /* Add extinction... */
00054     for (iw = 0; iw < ctl->nw; iw++)
00055         atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                   atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058     return n;
00059 }

```

Here is the call graph for this function:



**5.15.2.2** `void atm2x_help ( atm_t * atm, double zmin, double zmax, double * value, int val_iqa, gsl_vector * x, int * iqa, int * ipa, size_t * n )`

Add elements to state vector.

Definition at line 63 of file [jurassic.c](#).

```
00072         {
00073
00074     int ip;
00075
00076     /* Add elements to state vector... */
00077     for (ip = 0; ip < atm->np; ip++)
00078         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079             if (x != NULL)
00080                 gsl_vector_set(x, *n, value[ip]);
00081             if (iqa != NULL)
00082                 iqa[*n] = val_iqa;
00083             if (ipa != NULL)
00084                 ipa[*n] = ip;
00085             (*n)++;
00086         }
00087 }
```

**5.15.2.3** `double brightness ( double rad, double nu )`

Compute brightness temperature.

Definition at line 91 of file [jurassic.c](#).

```
00093     {
00094
00095     return C2 * nu / gsl_log1p(C1 * POW3(nu) / rad);
00096 }
```

**5.15.2.4** `void cart2geo ( double * x, double * z, double * lon, double * lat )`

Convert Cartesian coordinates to geolocation.

Definition at line 101 of file [jurassic.c](#).

```
00105     {
00106
00107     double radius;
00108
00109     radius = NORM(x);
00110     *lat = asin(x[2] / radius) * 180 / M_PI;
00111     *lon = atan2(x[1], x[0]) * 180 / M_PI;
00112     *z = radius - RE;
00113 }
```



### 5.15.2.5 void climatology ( ctl\_t\* *ctl*, atm\_t\* *atm\_mean* )

Interpolate climatological data.

Definition at line 117 of file [jurassic.c](#).

```

00119         {
00120
00121     static double z[121] = {
00122         0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00123         20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,
00124         38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125         56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126         74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127         92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128         108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129     };
00130
00131     static double pre[121] = {
00132         1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133         357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134         104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135         29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136         10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137         3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138         1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139         0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140         0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141         0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142         0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143         0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144         0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145         0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146         0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147         0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148         9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149         4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150         2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151     };
00152
00153     static double tem[121] = {
00154         285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155         229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156         215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157         222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158         241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159         262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160         258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161         237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162         220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163         207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164         190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165         178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166         201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167         272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168     };
00169
00170     static double c2h2[121] = {
00171         1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172         2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173         5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174         2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175         9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176         1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177         1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178         1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179         2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183     };
00184
00185     static double c2h6[121] = {
00186         2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187         1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188         5.503e-10, 4.87e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189         2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190         2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191         1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192         5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193         2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194         1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195         7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,

```

```
00196     3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197     1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198     4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199     1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200     3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00203 };
00204
00205 static double ccl4[121] = {
00206     1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207     1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208     8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209     3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210     3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
00211     4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220     1e-14, 1e-14, 1e-14
00221 };
00222
00223 static double ch4[121] = {
00224     1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225     1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226     1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227     1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228     1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229     8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230     6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231     4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232     3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233     2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234     1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235     1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236     1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237     9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238     7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239     5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240     4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241     3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242     2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243     2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244     1.782e-08
00245 };
00246
00247 static double clo[121] = {
00248     7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249     6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250     8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251     2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252     1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253     2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254     4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255     5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256     3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257     1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258     6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259     2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260     8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261     3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262     1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263     3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264     1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265     3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266     1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267     5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268     3.148e-15
00269 };
00270
00271 static double clono2[121] = {
00272     1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273     1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274     2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275     2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276     8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277     6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278     1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279     1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280     1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281     1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282     9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
```

```
00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293 };
00294
00295 static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
00298     5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299     2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300     1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301     2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302     3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303     3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304     6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305     2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306     8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307     2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308     3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309     6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310     1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311     1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312     3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313     5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314     6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315     7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05,
00316 };
00317
00318 static double cof2[121] = {
00319     7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320     6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321     7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322     4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323     1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324     1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325     1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326     8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327     5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328     2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329     7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330     1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331     4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332     1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333     2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334     4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335     7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336     1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337     3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338     1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339     4.662e-18
00340 };
00341
00342 static double f11[121] = {
00343     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345     2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346     1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347     7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348     5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349     1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350     3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351     6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352     1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353     1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354     2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355     2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356     2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357     2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358     1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359     1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360     1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361     2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362     4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363 };
00364
00365 static double f12[121] = {
00366     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368     5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369     4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
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00370     2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371     5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372     2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373     8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374     3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375     1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376     8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377     4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378     2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379     9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380     4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381     1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382     7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383     3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384     1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
00385     1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386 };
00387
00388 static double f14[121] = {
00389     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391     8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11
00406 };
00407
00408 static double f22[121] = {
00409     1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410     1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411     1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412     7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413     4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414     3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415     1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416     1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417     8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418     5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419     4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420     3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421     3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422     2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423     2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424     2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425     1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426     1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427     1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428     1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429 };
00430
00431 static double h2o[121] = {
00432     0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433     0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434     6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435     4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436     4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437     5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438     5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439     6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440     6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441     6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442     5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443     4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444     3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445     2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446     1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447     5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448     1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449     7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450     3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451     1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452 };
00453
00454 static double h2o2[121] = {
00455     1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456     4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
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00457 3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458 1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459 8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460 1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461 1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462 6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463 5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464 4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465 3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466 2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467 1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468 1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469 9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470 7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471 4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
00472 3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473 2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474 2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475 1.775e-12
00476 };
00477
00478 static double hcn[121] = {
00479 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481 5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482 1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483 1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484 1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485 1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486 1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487 1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488 9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489 8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490 7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491 6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492 6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493 6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494 6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495 5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496 5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497 5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498 5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499 };
00500
00501 static double hno3[121] = {
00502 1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503 2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504 5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505 3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506 8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507 3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508 8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509 1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510 6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511 3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512 1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513 9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514 5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515 2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516 1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517 5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518 2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519 1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520 5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521 3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522 2.332e-14
00523 };
00524
00525 static double hno4[121] = {
00526 6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527 1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528 3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529 1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530 2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531 1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532 3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533 2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534 1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535 2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536 1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537 5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538 2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539 8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540 3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541 1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542 3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543 1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
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00544     5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545     2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546     1.64e-18
00547 };
00548
00549 static double hoc1[121] = {
00550     1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551     2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552     5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553     1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554     4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555     7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556     1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557     6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558     1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
00559     3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560     6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561     1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562     1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563     2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564     3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565     4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566     5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567     6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568     9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569     2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570     7.881e-21
00571 };
00572
00573 static double n2o[121] = {
00574     3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575     3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576     2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577     2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578     1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579     7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580     2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581     1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582     5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583     2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584     1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585     1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586     9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587     7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588     5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589     4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590     3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591     2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592     2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593     2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594 };
00595
00596 static double n2o5[121] = {
00597     1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598     1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599     4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600     7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601     3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602     2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603     2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604     6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612     1e-16, 1e-16
00613 };
00614
00615 static double nh3[121] = {
00616     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617     1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618     4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619     5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620     6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621     1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622     1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623     1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624     2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
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00631      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634      1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635      1.914e-17
00636  };
00637
00638  static double no[121] = {
00639      2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640      1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641      7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642      1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643      8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644      5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645      1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,
00646      1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647      9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648      3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649      8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650      1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651      2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652      1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653      7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654      6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655      3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656      1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657      5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658      9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659      0.0001133
00660  };
00661
00662  static double no2[121] = {
00663      3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664      2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665      9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666      9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667      3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668      7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669      7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670      2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671      2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672      3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673      6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674      9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675      2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676      1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677      9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678      9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679      9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680      9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681  };
00682
00683  static double o3[121] = {
00684      2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685      5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686      1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687      1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688      4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689      6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690      7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691      5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692      3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693      1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694      9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695      4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696      2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697      2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698      3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699      8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700      8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701      3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702      6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703      5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704      3.665e-10
00705  };
00706
00707  static double ocs[121] = {
00708      6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709      5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710      4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711      1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712      1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713      5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714      1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715      1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716      1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717      1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,

```

```

00718     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727     1.091e-14, 1.091e-14, 1.091e-14
00728 };
00729
00730 static double sf6[121] = {
00731     4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732     4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750 };
00751
00752 static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768 };
00769
00770 static int ig_co2 = -999;
00771
00772 double co2, *q[NG] = { NULL };
00773
00774 int ig, ip, iw, iz;
00775
00776 /* Find emitter index of CO2... */
00777 if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780 /* Identify variable... */
00781 for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784         q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786         q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788         q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790         q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792         q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794         q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796         q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798         q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800         q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802         q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804         q[ig] = f14;

```

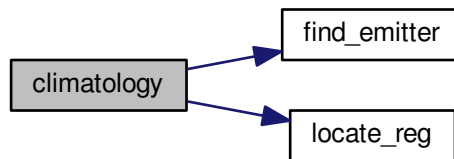


```

00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806         q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808         q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810         q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812         q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814         q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816         q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOCl") == 0)
00818         q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)
00820         q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822         q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824         q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826         q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828         q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830         q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832         q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834         q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836         q[ig] = so2;
00837 }
00838
00839 /* Loop over atmospheric data points... */
00840 for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853         if (q[ig] != NULL)
00854             atm->q[ig][ip] =
00855                 LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856         else
00857             atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861         co2 =
00862             371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863         atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868         atm->k[iw][ip] = 0;
00869 }
00870 }

```

Here is the call graph for this function:



#### 5.15.2.6 double ctmco2 ( double *nu*, double *p*, double *t*, double *u* )

Compute carbon dioxide continuum (optical depth).

Definition at line 874 of file [jurassic.c](#).

```

00878     {
00879
00880     static double co2296[2001] = { 9.3388e-5, 9.7711e-5, 1.0224e-4, 1.0697e-4,
00881     1.1193e-4, 1.1712e-4, 1.2255e-4, 1.2824e-4, 1.3419e-4, 1.4043e-4,
00882     1.4695e-4, 1.5378e-4, 1.6094e-4, 1.6842e-4, 1.7626e-4, 1.8447e-4,
00883     1.9307e-4, 2.0207e-4, 2.1149e-4, 2.2136e-4, 2.3169e-4, 2.4251e-4,
00884     2.5384e-4, 2.657e-4, 2.7813e-4, 2.9114e-4, 3.0477e-4, 3.1904e-4,
00885     3.3399e-4, 3.4965e-4, 3.6604e-4, 3.8322e-4, 4.0121e-4, 4.2006e-4,
00886     4.398e-4, 4.6047e-4, 4.8214e-4, 5.0483e-4, 5.286e-4, 5.535e-4,
00887     5.7959e-4, 6.0693e-4, 6.3557e-4, 6.6558e-4, 6.9702e-4, 7.2996e-4,
00888     7.6449e-4, 8.0066e-4, 8.3856e-4, 8.7829e-4, 9.1991e-4, 9.6354e-4,
00889     .0010093, .0010572, .0011074, .00116, .0012152, .001273,
00890     .0013336, .0013972, .0014638, .0015336, .0016068, .0016835,
00891     .001764, .0018483, .0019367, .0020295, .0021267, .0022286,
00892     .0023355, .0024476, .0025652, .0026885, .0028178, .0029534,
00893     .0030956, .0032448, .0034012, .0035654, .0037375, .0039181,
00894     .0041076, .0043063, .0045148, .0047336, .0049632, .005204,
00895     .0054567, .0057219, .0060002, .0062923, .0065988, .0069204,
00896     .007258, .0076123, .0079842, .0083746, .0087844, .0092146,
00897     .0096663, .01014, .010638, .011161, .01171, .012286, .012891,
00898     .013527, .014194, .014895, .015631, .016404, .017217, .01807,
00899     .018966, .019908, .020897, .021936, .023028, .024176, .025382,
00900     .026649, .027981, .02938, .030851, .032397, .034023, .035732,
00901     .037528, .039416, .041402, .04349, .045685, .047994, .050422,
00902     .052975, .055661, .058486, .061458, .064584, .067873, .071334,
00903     .074975, .078807, .082839, .087082, .091549, .096249, .1012,
00904     .10641, .11189, .11767, .12375, .13015, .13689, .14399, .15147,
00905     .15935, .16765, .17639, .18561, .19531, .20554, .21632, .22769,
00906     .23967, .25229, .2656, .27964, .29443, .31004, .3265, .34386,
00907     .36218, .3815, .40188, .42339, .44609, .47004, .49533, .52202,
00908     .5502, .57995, .61137, .64455, .6796, .71663, .75574, .79707,
00909     .84075, .88691, .9357, .98728, 1.0418, 1.0995, 1.1605, 1.225,
00910     1.2932, 1.3654, 1.4418, 1.5227, 1.6083, 1.6989, 1.7948, 1.8964,
00911     2.004, 2.118, 2.2388, 2.3668, 2.5025, 2.6463, 2.7988, 2.9606,
00912     3.1321, 3.314, 3.5071, 3.712, 3.9296, 4.1605, 4.4058, 4.6663,
00913     4.9431, 5.2374, 5.5501, 5.8818, 6.2353, 6.6114, 7.0115, 7.4372,
00914     7.8905, 8.3731, 8.8871, 9.4349, 10.019, 10.641, 11.305, 12.013,
00915     12.769, 13.576, 14.437, 15.358, 16.342, 17.39, 18.513, 19.716,
00916     21.003, 22.379, 23.854, 25.436, 27.126, 28.942, 30.89, 32.973,
00917     35.219, 37.634, 40.224, 43.021, 46.037, 49.29, 52.803, 56.447,
00918     60.418, 64.792, 69.526, 74.637, 80.182, 86.193, 92.713, 99.786,
00919     107.47, 115.84, 124.94, 134.86, 145.69, 157.49, 170.3, 184.39,
00920     199.83, 216.4, 234.55, 254.72, 276.82, 299.85, 326.16, 354.99,
00921     386.51, 416.68, 449.89, 490.12, 534.35, 578.25, 632.26, 692.61,
00922     756.43, 834.75, 924.11, 1016.9, 996.96, 1102.7, 1219.2, 1351.9,
00923     1494.3, 1654.1, 1826.5, 2027.9, 2249., 2453.8, 2714.4, 2999.4,
00924     3209.5, 3509., 3840.4, 3907.5, 4190.7, 4533.5, 4648.3, 5059.1,
00925     5561.6, 6191.4, 6820.8, 7905.9, 9362.2, 2431.3, 2211.3, 2046.8,
00926     2023.8, 1985.9, 1905.9, 1491.1, 1369.8, 1262.2, 1200.7, 887.74,
00927     820.25, 885.23, 887.21, 816.73, 1126.9, 1216.2, 1272.4, 1579.5,
00928     1634.2, 1656.3, 1657.9, 1789.5, 1670.8, 1509.5, 8474.6, 7489.2,
00929     6793.6, 6117., 5574.1, 5141.2, 5084.6, 4745.1, 4413.2, 4102.8,
  
```

00930 4024.7, 3715., 3398.6, 3100.8, 2900.4, 2629.2, 2374., 2144.7,  
 00931 1955.8, 1760.8, 1591.2, 1435.2, 1296.2, 1174., 1065.1, 967.76,  
 00932 999.48, 897.45, 809.23, 732.77, 670.26, 611.93, 560.11, 518.77,  
 00933 476.84, 438.8, 408.48, 380.21, 349.24, 322.71, 296.65, 272.85,  
 00934 251.96, 232.04, 213.88, 197.69, 182.41, 168.41, 155.79, 144.05,  
 00935 133.31, 123.48, 114.5, 106.21, 98.591, 91.612, 85.156, 79.204,  
 00936 73.719, 68.666, 63.975, 59.637, 56.35, 52.545, 49.042, 45.788,  
 00937 42.78, 39.992, 37.441, 35.037, 32.8, 30.744, 28.801, 26.986,  
 00938 25.297, 23.731, 22.258, 20.883, 19.603, 18.403, 17.295, 16.249,  
 00939 15.271, 14.356, 13.501, 12.701, 11.954, 11.254, 10.6, 9.9864,  
 00940 9.4118, 8.8745, 8.3714, 7.8997, 7.4578, 7.0446, 6.6573, 6.2949,  
 00941 5.9577, 5.6395, 5.3419, 5.063, 4.8037, 4.5608, 4.3452, 4.1364,  
 00942 3.9413, 3.7394, 3.562, 3.3932, 3.2325, 3.0789, 2.9318, 2.7898,  
 00943 2.6537, 2.5225, 2.3958, 2.2305, 2.1215, 2.0245, 1.9427, 1.8795,  
 00944 1.8336, 1.7604, 1.7016, 1.6419, 1.5282, 1.4611, 1.3443, 1.27,  
 00945 1.1675, 1.0824, 1.0534, .99833, .95854, .92981, .90887, .89346,  
 00946 .88113, .87068, .86102, .85096, .88262, .86151, .83565, .80518,  
 00947 .77045, .73736, .74744, .74954, .75773, .82267, .83493, .89402,  
 00948 .89725, .93426, .95564, .94045, .94174, .93404, .92035, .90456,  
 00949 .88621, .86673, .78117, .7515, .72056, .68822, .65658, .62764,  
 00950 .55984, .55598, .57407, .60963, .63763, .66198, .61132, .60972,  
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01581 35.682, 36.755, 38.111, 39.703, 41.58, 43.606, 45.868, 48.573,
01582 51.298, 54.291, 57.559, 61.116, 64.964, 69.124, 73.628, 78.471,
01583 83.683, 89.307, 95.341, 101.84, 108.83, 116.36, 124.46, 133.18,
01584 142.57, 152.79, 163.69, 175.43, 188.11, 201.79, 216.55, 232.51,
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01586 449.88, 485.2, 523.54, 565.14, 610.28, 659.31, 712.56, 770.43,
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01655 .0076269, .0063758, .006254, .0067749, .0067909, .0068231,
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01703 1.4731, 1.3794, 1.2921, 1.2107, 1.1346, 1.0637, .99744, .93554,
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01705 .53086, .49883, .46881, .44074, .4144, .38979, .36679, .34513,
01706 .32474, .30552, .28751, .27045, .25458, .23976, .22584, .21278,
01707 .20051, .18899, .17815, .16801, .15846, .14954, .14117, .13328,
01708 .12584
01709 };
01710
01711 double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmph;
01712

```

```

01713     int iw;
01714
01715     /* Get CO2 continuum absorption... */
01716     xw = nu / 2 + 1;
01717     if (xw >= 1 && xw < 2001) {
01718         iw = (int) xw;
01719         dw = xw - iw;
01720         ew = 1 - dw;
01721         cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722         cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723         cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724         dt230 = t - 230;
01725         dt260 = t - 260;
01726         dt296 = t - 296;
01727         ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728             * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729         ctmph = u / NA / 1000 * p / P0 * ctw;
01730     } else
01731         ctmph = 0;
01732     return ctmph;
01733 }

```

### 5.15.2.7 double ctmh2o ( double nu, double p, double t, double q, double u )

Compute water vapor continuum (optical depth).

Definition at line 1737 of file [jurassic.c](#).

```

01742     {
01743
01744     static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745     .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746     .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747     .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748     .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749     .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750     .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
01751     6.4e-4, 5.687e-4, 5.063e-4, 4.511e-4, 4.029e-4, 3.596e-4,
01752     3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753     1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754     1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
01755     6.433e-5, 6.013e-5, 5.631e-5, 5.283e-5, 4.963e-5, 4.669e-5,
01756     4.398e-5, 4.148e-5, 3.917e-5, 3.702e-5, 3.502e-5, 3.316e-5,
01757     3.142e-5, 2.978e-5, 2.825e-5, 2.681e-5, 2.546e-5, 2.419e-5,
01758     2.299e-5, 2.186e-5, 2.079e-5, 1.979e-5, 1.884e-5, 1.795e-5,
01759     1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
01760     1.312e-5, 1.263e-5, 1.218e-5, 1.178e-5, 1.143e-5, 1.112e-5,
01761     1.088e-5, 1.07e-5, 1.057e-5, 1.05e-5, 1.051e-5, 1.059e-5,
01762     1.076e-5, 1.1e-5, 1.133e-5, 1.18e-5, 1.237e-5, 1.308e-5,
01763     1.393e-5, 1.483e-5, 1.614e-5, 1.758e-5, 1.93e-5, 2.123e-5,
01764     2.346e-5, 2.647e-5, 2.93e-5, 3.279e-5, 3.745e-5, 4.152e-5,
01765     4.813e-5, 5.477e-5, 6.203e-5, 7.331e-5, 8.056e-5, 9.882e-5,
01766     1.05e-4, 1.21e-4, 1.341e-4, 1.572e-4, 1.698e-4, 1.968e-4,
01767     2.175e-4, 2.431e-4, 2.735e-4, 2.867e-4, 3.19e-4, 3.371e-4,
01768     3.554e-4, 3.726e-4, 3.837e-4, 3.878e-4, 3.864e-4, 3.858e-4,
01769     3.841e-4, 3.852e-4, 3.815e-4, 3.762e-4, 3.618e-4, 3.579e-4,
01770     3.45e-4, 3.202e-4, 3.018e-4, 2.785e-4, 2.602e-4, 2.416e-4,
01771     2.097e-4, 1.939e-4, 1.689e-4, 1.498e-4, 1.308e-4, 1.17e-4,
01772     1.011e-4, 9.237e-5, 7.909e-5, 7.006e-5, 6.112e-5, 5.401e-5,
01773     4.914e-5, 4.266e-5, 3.963e-5, 3.316e-5, 3.037e-5, 2.598e-5,
01774     2.294e-5, 2.066e-5, 1.813e-5, 1.583e-5, 1.423e-5, 1.247e-5,
01775     1.116e-5, 9.76e-6, 8.596e-6, 7.72e-6, 6.825e-6, 6.108e-6,
01776     5.366e-6, 4.733e-6, 4.229e-6, 3.731e-6, 3.346e-6, 2.972e-6,
01777     2.628e-6, 2.356e-6, 2.102e-6, 1.878e-6, 1.678e-6, 1.507e-6,
01778     1.348e-6, 1.21e-6, 1.089e-6, 9.806e-7, 8.857e-7, 8.004e-7,
01779     7.261e-7, 6.599e-7, 6.005e-7, 5.479e-7, 5.011e-7, 4.595e-7,
01780     4.219e-7, 3.885e-7, 3.583e-7, 3.314e-7, 3.071e-7, 2.852e-7,
01781     2.654e-7, 2.474e-7, 2.311e-7, 2.162e-7, 2.026e-7, 1.902e-7,
01782     1.788e-7, 1.683e-7, 1.587e-7, 1.497e-7, 1.415e-7, 1.338e-7,
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01784     9.296e-8, 8.862e-8, 8.458e-8, 8.087e-8, 7.744e-8, 7.429e-8,
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01786     6.07e-8, 5.992e-8, 5.913e-8, 5.841e-8, 5.796e-8, 5.757e-8,
01787     5.746e-8, 5.731e-8, 5.679e-8, 5.577e-8, 5.671e-8, 5.656e-8,
01788     5.594e-8, 5.593e-8, 5.602e-8, 5.62e-8, 5.693e-8, 5.725e-8,
01789     5.858e-8, 6.037e-8, 6.249e-8, 6.535e-8, 6.899e-8, 7.356e-8,
01790     7.918e-8, 8.618e-8, 9.385e-8, 1.039e-7, 1.158e-7, 1.29e-7,
01791     1.437e-7, 1.65e-7, 1.871e-7, 2.121e-7, 2.427e-7, 2.773e-7,
01792     3.247e-7, 3.677e-7, 4.037e-7, 4.776e-7, 5.101e-7, 6.214e-7,
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02661 4.955e-13, 6.303e-13, 7.861e-13, 9.427e-13, 1.097e-12, 1.212e-12,
02662 1.328e-12, 1.415e-12, 1.463e-12, 1.495e-12, 1.571e-12, 1.731e-12,
02663 1.981e-12, 2.387e-12, 2.93e-12, 3.642e-12, 4.584e-12, 5.822e-12,
```

```

02664    7.278e-12, 9.193e-12, 1.135e-11, 1.382e-11, 1.662e-11, 1.958e-11,
02665    2.286e-11, 2.559e-11, 2.805e-11, 2.988e-11, 3.106e-11, 3.182e-11,
02666    3.2e-11, 3.258e-11, 3.362e-11, 3.558e-11, 3.688e-11, 3.8e-11,
02667    3.929e-11, 4.062e-11, 4.186e-11, 4.293e-11, 4.48e-11, 4.643e-11,
02668    4.704e-11, 4.571e-11, 4.206e-11, 3.715e-11, 3.131e-11, 2.541e-11,
02669    1.978e-11, 1.508e-11, 1.146e-11, 8.7e-12, 6.603e-12, 5.162e-12,
02670    4.157e-12, 3.408e-12, 2.829e-12, 2.405e-12, 2.071e-12, 1.826e-12,
02671    1.648e-12, 1.542e-12, 1.489e-12, 1.485e-12, 1.493e-12, 1.545e-12,
02672    1.637e-12, 1.814e-12, 2.061e-12, 2.312e-12, 2.651e-12, 3.03e-12,
02673    3.46e-12, 3.901e-12, 4.306e-12, 4.721e-12, 5.008e-12, 5.281e-12,
02674    5.541e-12, 5.791e-12, 6.115e-12, 6.442e-12, 6.68e-12, 6.791e-12,
02675    6.831e-12, 6.839e-12, 6.946e-12, 7.128e-12, 7.537e-12, 8.036e-12,
02676    8.392e-12, 8.526e-12, 8.11e-12, 7.325e-12, 6.329e-12, 5.183e-12,
02677    4.081e-12, 2.985e-12, 2.141e-12, 1.492e-12, 1.015e-12, 6.684e-13,
02678    4.414e-13, 2.987e-13, 2.038e-13, 1.391e-13, 9.86e-14, 7.24e-14,
02679    5.493e-14, 4.288e-14, 3.427e-14, 2.787e-14, 2.296e-14, 1.909e-14,
02680    1.598e-14, 1.344e-14, 1.135e-14, 9.616e-15, 8.169e-15, 6.957e-15,
02681    5.938e-15, 5.08e-15, 4.353e-15, 3.738e-15, 3.217e-15, 2.773e-15,
02682    2.397e-15, 2.077e-15, 1.805e-15, 1.575e-15, 1.382e-15, 1.221e-15,
02683    1.09e-15, 9.855e-16, 9.068e-16, 8.537e-16, 8.27e-16, 8.29e-16,
02684    8.634e-16, 9.359e-16, 1.055e-15, 1.233e-15, 1.486e-15, 1.839e-15,
02685    2.326e-15, 2.998e-15, 3.934e-15, 5.256e-15, 7.164e-15, 9.984e-15,
02686    1.427e-14, 2.099e-14, 3.196e-14, 5.121e-14, 7.908e-14, 1.131e-13,
02687    1.602e-13, 2.239e-13, 3.075e-13, 4.134e-13, 5.749e-13, 7.886e-13,
02688    1.071e-12, 1.464e-12, 2.032e-12, 2.8e-12, 3.732e-12, 4.996e-12,
02689    6.483e-12, 8.143e-12, 1.006e-11, 1.238e-11, 1.484e-11, 1.744e-11,
02690    2.02e-11, 2.274e-11, 2.562e-11, 2.848e-11, 3.191e-11, 3.617e-11,
02691    4.081e-11, 4.577e-11, 4.937e-11, 5.204e-11, 5.401e-11, 5.462e-11,
02692    5.507e-11, 5.51e-11, 5.605e-11, 5.686e-11, 5.739e-11, 5.766e-11,
02693    5.74e-11, 5.754e-11, 5.761e-11, 5.777e-11, 5.712e-11, 5.51e-11,
02694    5.088e-11, 4.438e-11, 3.728e-11, 2.994e-11, 2.305e-11, 1.715e-11,
02695    1.256e-11, 9.208e-12, 6.745e-12, 5.014e-12, 3.785e-12, 2.9e-12,
02696    2.239e-12, 1.757e-12, 1.414e-12, 1.142e-12, 9.482e-13, 8.01e-13,
02697    6.961e-13, 6.253e-13, 5.735e-13, 5.433e-13, 5.352e-13, 5.493e-13,
02698    5.706e-13, 6.068e-13, 6.531e-13, 7.109e-13, 7.767e-13, 8.59e-13,
02699    9.792e-13, 1.142e-12, 1.371e-12, 1.65e-12, 1.957e-12, 2.302e-12,
02700    2.705e-12, 3.145e-12, 3.608e-12, 4.071e-12, 4.602e-12, 5.133e-12,
02701    5.572e-12, 5.987e-12, 6.248e-12, 6.533e-12, 6.757e-12, 6.935e-12,
02702    7.224e-12, 7.422e-12, 7.538e-12, 7.547e-12, 7.495e-12, 7.543e-12,
02703    7.725e-12, 8.139e-12, 8.627e-12, 9.146e-12, 9.443e-12, 9.318e-12,
02704    8.649e-12, 7.512e-12, 6.261e-12, 4.915e-12, 3.647e-12, 2.597e-12,
02705    1.785e-12, 1.242e-12, 8.66e-13, 6.207e-13, 4.61e-13, 3.444e-13,
02706    2.634e-13, 2.1e-13, 1.725e-13, 1.455e-13, 1.237e-13, 1.085e-13,
02707    9.513e-14, 7.978e-14, 6.603e-14, 5.288e-14, 4.084e-14, 2.952e-14,
02708    2.157e-14, 1.593e-14, 1.199e-14, 9.267e-15, 7.365e-15, 6.004e-15,
02709    4.995e-15, 4.218e-15, 3.601e-15, 3.101e-15, 2.692e-15, 2.36e-15,
02710    2.094e-15, 1.891e-15, 1.755e-15, 1.699e-15, 1.755e-15, 1.987e-15,
02711    2.506e-15, 3.506e-15, 5.289e-15, 8.311e-15, 1.325e-14, 2.129e-14,
02712    3.237e-14, 4.595e-14, 6.441e-14, 8.433e-14, 1.074e-13, 1.383e-13,
02713    1.762e-13, 2.281e-13, 2.831e-13, 3.523e-13, 4.38e-13, 5.304e-13,
02714    6.29e-13, 7.142e-13, 8.032e-13, 8.934e-13, 9.888e-13, 1.109e-12,
02715    1.261e-12, 1.462e-12, 1.74e-12, 2.099e-12, 2.535e-12, 3.008e-12,
02716    3.462e-12, 3.856e-12, 4.098e-12, 4.239e-12, 4.234e-12, 4.132e-12,
02717    3.986e-12, 3.866e-12, 3.829e-12, 3.742e-12, 3.705e-12, 3.694e-12,
02718    3.765e-12, 3.849e-12, 3.929e-12, 4.056e-12, 4.092e-12, 4.047e-12,
02719    3.792e-12, 3.407e-12, 2.953e-12, 2.429e-12, 1.931e-12, 1.46e-12,
02720    1.099e-12, 8.199e-13, 6.077e-13, 4.449e-13, 3.359e-13, 2.524e-13,
02721    1.881e-13, 1.391e-13, 1.02e-13, 7.544e-14, 5.555e-14, 4.22e-14,
02722    3.321e-14, 2.686e-14, 2.212e-14, 1.78e-14, 1.369e-14, 1.094e-14,
02723    9.13e-15, 8.101e-15, 7.828e-15, 8.393e-15, 1.012e-14, 1.259e-14,
02724    1.538e-14, 1.961e-14, 2.619e-14, 3.679e-14, 5.049e-14, 6.917e-14,
02725    8.88e-14, 1.115e-13, 1.373e-13, 1.619e-13, 1.878e-13, 2.111e-13,
02726    2.33e-13, 2.503e-13, 2.613e-13, 2.743e-13, 2.826e-13, 2.976e-13,
02727    3.162e-13, 3.36e-13, 3.491e-13, 3.541e-13, 3.595e-13, 3.608e-13,
02728    3.709e-13, 3.869e-13, 4.12e-13, 4.366e-13, 4.504e-13, 4.379e-13,
02729    3.955e-13, 3.385e-13, 2.741e-13, 2.089e-13, 1.427e-13, 9.294e-14,
02730    5.775e-14, 3.565e-14, 2.21e-14, 1.398e-14, 9.194e-15, 6.363e-15,
02731    4.644e-15, 3.55e-15, 2.808e-15, 2.274e-15, 1.871e-15, 1.557e-15,
02732    1.308e-15, 1.108e-15, 9.488e-16, 8.222e-16, 7.238e-16, 6.506e-16,
02733    6.008e-16, 5.742e-16, 5.724e-16, 5.991e-16, 6.625e-16, 7.775e-16,
02734    9.734e-16, 1.306e-15, 1.88e-15, 2.879e-15, 4.616e-15, 7.579e-15,
02735    1.248e-14, 2.03e-14, 3.244e-14, 5.171e-14, 7.394e-14, 9.676e-14,
02736    1.199e-13, 1.467e-13, 1.737e-13, 2.02e-13, 2.425e-13, 3.016e-13,
02737    3.7e-13, 4.617e-13, 5.949e-13, 7.473e-13, 9.378e-13, 1.191e-12,
02738    1.481e-12, 1.813e-12, 2.232e-12, 2.722e-12, 3.254e-12, 3.845e-12,
02739    4.458e-12, 5.048e-12, 5.511e-12, 5.898e-12, 6.204e-12, 6.293e-12,
02740    6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741    6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742    7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743    2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744    4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745    };
02746
02747    static double xfcrev[15] =
02748    { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749      1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750    };

```

```

02751
02752 double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753 sfac, fscal, cwfrn, ctmph, ctwfrn, ctwsf;
02754
02755 int iw, ix;
02756
02757 /* Get H2O continuum absorption... */
02758 xw = nu / 10 + 1;
02759 if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767         sfac = 1;
02768     } else {
02769         xx = (nu - 820) / 10;
02770         ix = (int) xx;
02771         dx = xx - ix;
02772         sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctwsf = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctwsf + (1 - q) * ctwfrn) * 1e-20;
02782     ctmph = a1 * a2 * a3;
02783 } else
02784     ctmph = 0;
02785 return ctmph;
02786 }

```

#### 5.15.2.8 double ctmn2 ( double nu, double p, double t )

Compute nitrogen continuum (absorption coefficient).

Definition at line 2790 of file [jurassic.c](#).

```

02793 {
02794
02795 static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796 1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797 2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798 5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799 7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800 9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801 1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802 1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803 1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804 1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805 7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806 3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807 1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808 7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809 };
02810
02811 static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812 511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813 233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814 -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815 -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816 -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817 -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818 121., 141., 152., 161., 164., 164., 161., 155., 148., 143., 137.,
02819 133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820 372., 449., 514., 569., 609., 642., 673., 673.
02821 };
02822
02823 static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824 2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825 2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826 2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827 2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828 2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829 2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,

```



```

02830      2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831      2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832      2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833      2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834  };
02835
02836  double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838  int idx;
02839
02840  /* Check wavenumber range... */
02841  if (nu < nua[0] || nu > nua[97])
02842      return 0;
02843
02844  /* Interpolate B and beta... */
02845  idx = locate_reg(nua, 98, nu);
02846  b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847  beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849  /* Compute absorption coefficient... */
02850  return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851      * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }

```

Here is the call graph for this function:



#### 5.15.2.9 double ctmo2 ( double nu, double p, double t )

Compute oxygen continuum (absorption coefficient).

Definition at line 2856 of file [jurassic.c](#).

```

02859      {
02860
02861      static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862      .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863      1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864      2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865      4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866      3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867      2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868      1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869      .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870      .071, .064, 0.
02871  };
02872
02873  static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874  531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875  193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876  -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877  -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878  -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879  123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880  321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881  346., 322., 291., 290., 350., 371., 504., 504.
02882  };
02883
02884  static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885  1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886  1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887  1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888  1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,

```

```

02889     1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890     1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891     1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892     1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893     1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894     1800., 1805.
02895 };
02896
02897 double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899 int idx;
02900
02901 /* Check wavenumber range... */
02902 if (nu < nua[0] || nu > nua[89])
02903     return 0;
02904
02905 /* Interpolate B and beta... */
02906 idx = locate_reg(nua, 90, nu);
02907 b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02908 beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910 /* Compute absorption coefficient... */
02911 return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912     b;
02913 }

```

Here is the call graph for this function:



#### 5.15.2.10 void copy\_atm ( ctl\_t \* ctl, atm\_t \* atm\_dest, atm\_t \* atm\_src, int init )

Copy and initialize atmospheric data.

Definition at line 2917 of file [jurassic.c](#).

```

02921     {
02922
02923     int ig, ip, iw;
02924
02925     size_t s;
02926
02927     /* Data size... */
02928     s = (size_t) atm_src->np * sizeof(double);
02929
02930     /* Copy data... */
02931     atm_dest->np = atm_src->np;
02932     memcpy(atm_dest->time, atm_src->time, s);
02933     memcpy(atm_dest->z, atm_src->z, s);
02934     memcpy(atm_dest->lon, atm_src->lon, s);
02935     memcpy(atm_dest->lat, atm_src->lat, s);
02936     memcpy(atm_dest->p, atm_src->p, s);
02937     memcpy(atm_dest->t, atm_src->t, s);
02938     for (ig = 0; ig < ctl->ng; ig++)
02939         memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940     for (iw = 0; iw < ctl->nw; iw++)
02941         memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943     /* Initialize... */
02944     if (init)
02945         for (ip = 0; ip < atm_dest->np; ip++) {
02946             atm_dest->p[ip] = 0;
02947             atm_dest->t[ip] = 0;
02948             for (ig = 0; ig < ctl->ng; ig++)
02949                 atm_dest->q[ig][ip] = 0;
02950             for (iw = 0; iw < ctl->nw; iw++)
02951                 atm_dest->k[iw][ip] = 0;
02952         }
02953 }

```

### 5.15.2.11 void copy\_obs ( ctl\_t \* *ctl*, obs\_t \* *obs\_dest*, obs\_t \* *obs\_src*, int *init* )

Copy and initialize observation data.

Definition at line 2957 of file [jurassic.c](#).

```

02961         {
02962
02963     int id, ir;
02964
02965     size_t s;
02966
02967     /* Data size... */
02968     s = (size_t) obs_src->nr * sizeof(double);
02969
02970     /* Copy data... */
02971     obs_dest->nr = obs_src->nr;
02972     memcpy(obs_dest->time, obs_src->time, s);
02973     memcpy(obs_dest->obsz, obs_src->obsz, s);
02974     memcpy(obs_dest->obslon, obs_src->obslon, s);
02975     memcpy(obs_dest->obslat, obs_src->obslat, s);
02976     memcpy(obs_dest->vpz, obs_src->vpz, s);
02977     memcpy(obs_dest->vplon, obs_src->vplon, s);
02978     memcpy(obs_dest->vplat, obs_src->vplat, s);
02979     memcpy(obs_dest->tpz, obs_src->tpz, s);
02980     memcpy(obs_dest->tplon, obs_src->tplon, s);
02981     memcpy(obs_dest->tplat, obs_src->tplat, s);
02982     for (id = 0; id < ctl->nd; id++)
02983         memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984     for (id = 0; id < ctl->nd; id++)
02985         memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987     /* Initialize... */
02988     if (init)
02989         for (id = 0; id < ctl->nd; id++)
02990             for (ir = 0; ir < obs_dest->nr; ir++)
02991                 if (gsl_finite(obs_dest->rad[id][ir])) {
02992                     obs_dest->rad[id][ir] = 0;
02993                     obs_dest->tau[id][ir] = 0;
02994                 }
02995 }
```

### 5.15.2.12 int find\_emitter ( ctl\_t \* *ctl*, const char \* *emitter* )

Find index of an emitter.

Definition at line 2999 of file [jurassic.c](#).

```

03001         {
03002
03003     int ig;
03004
03005     for (ig = 0; ig < ctl->ng; ig++)
03006         if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007             return ig;
03008
03009     return -1;
03010 }
```

### 5.15.2.13 void formod ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs* )

Determine ray paths and compute radiative transfer.

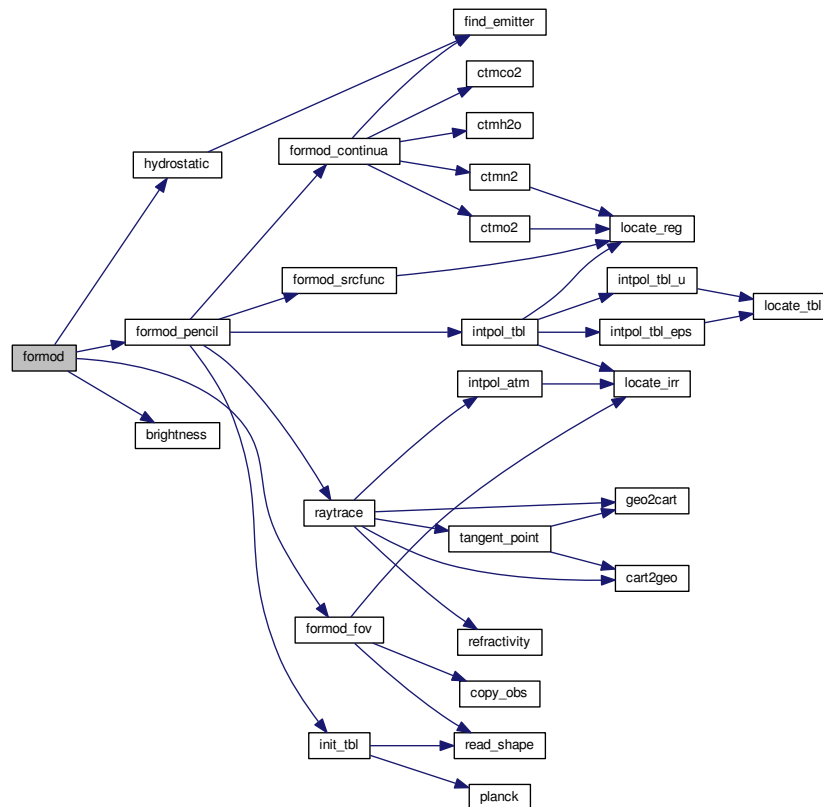
Definition at line 3014 of file [jurassic.c](#).

```

03017         {
03018
03019     int id, ir, *mask;
03020
03021     /* Allocate... */
03022     ALLOC(mask, int,
03023           ND * NR);
03024
03025     /* Save observation mask... */
03026     for (id = 0; id < ctl->nd; id++)
03027         for (ir = 0; ir < obs->nr; ir++)
03028             mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030     /* Hydrostatic equilibrium... */
03031     hydrostatic(ctl, atm);
03032
03033     /* Calculate pencil beams... */
03034     for (ir = 0; ir < obs->nr; ir++)
03035         formod_pencil(ctl, atm, obs, ir);
03036
03037     /* Apply field-of-view convolution... */
03038     formod_fov(ctl, obs);
03039
03040     /* Convert radiance to brightness temperature... */
03041     if (ctl->write_bbt)
03042         for (id = 0; id < ctl->nd; id++)
03043             for (ir = 0; ir < obs->nr; ir++)
03044                 obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046     /* Apply observation mask... */
03047     for (id = 0; id < ctl->nd; id++)
03048         for (ir = 0; ir < obs->nr; ir++)
03049             if (mask[id * NR + ir])
03050                 obs->rad[id][ir] = GSL_NAN;
03051
03052     /* Free... */
03053     free(mask);
03054 }

```

Here is the call graph for this function:



#### 5.15.2.14 void formod\_continua ( ctl\_t \* *ctl*, los\_t \* *los*, int *ip*, double \* *beta* )

Compute absorption coefficient of continua.

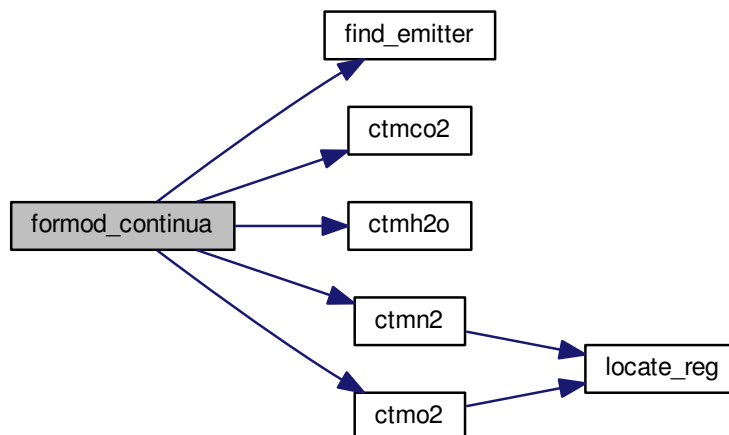
Definition at line 3058 of file [jurassic.c](#).

```

03062         {
03063
03064     static int ig_co2 = -999, ig_h2o = -999;
03065
03066     int id;
03067
03068     /* Extinction... */
03069     for (id = 0; id < ctl->nd; id++)
03070         beta[id] = los->k[ctl->window[id]][ip];
03071
03072     /* CO2 continuum... */
03073     if (ctl->ctm_co2) {
03074         if (ig_co2 == -999)
03075             ig_co2 = find_emitter(ctl, "CO2");
03076         if (ig_co2 >= 0)
03077             for (id = 0; id < ctl->nd; id++)
03078                 beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                                     los->u[ig_co2][ip]) / los->ds[ip];
03080     }
03081
03082     /* H2O continuum... */
03083     if (ctl->ctm_h2o) {
03084         if (ig_h2o == -999)
03085             ig_h2o = find_emitter(ctl, "H2O");
03086         if (ig_h2o >= 0)
03087             for (id = 0; id < ctl->nd; id++)
03088                 beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                                     los->q[ig_h2o][ip],
03090                                     los->u[ig_h2o][ip]) / los->ds[ip];
03091     }
03092
03093     /* N2 continuum... */
03094     if (ctl->ctm_n2)
03095         for (id = 0; id < ctl->nd; id++)
03096             beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098     /* O2 continuum... */
03099     if (ctl->ctm_o2)
03100         for (id = 0; id < ctl->nd; id++)
03101             beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }

```

Here is the call graph for this function:



5.15.2.15 void formod\_fov ( ctl\_t \* *ctl*, obs\_t \* *obs* )

Apply field of view convolution.

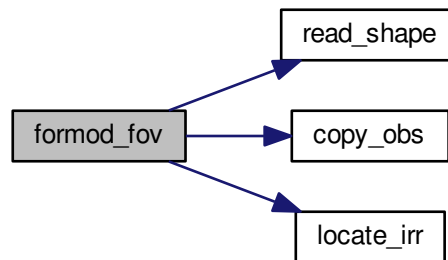
Definition at line 3106 of file [jurassic.c](#).

```

03108         {
03109
03110     static double dz[NSHAPE], w[NSHAPE];
03111
03112     static int init = 0, n;
03113
03114     obs_t *obs2;
03115
03116     double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03117
03118     int i, id, idx, ir, ir2, nz;
03119
03120     /* Do not take into account FOV... */
03121     if (ctl->fov[0] == '-')
03122         return;
03123
03124     /* Initialize FOV data... */
03125     if (!init) {
03126         init = 1;
03127         read_shape(ctl->fov, dz, w, &n);
03128     }
03129
03130     /* Allocate... */
03131     ALLOC(obs2, obs_t, 1);
03132
03133     /* Copy observation data... */
03134     copy_obs(ctl, obs2, obs, 0);
03135
03136     /* Loop over ray paths... */
03137     for (ir = 0; ir < obs->nr; ir++) {
03138
03139         /* Get radiance and transmittance profiles... */
03140         nz = 0;
03141         for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03142             ir2++)
03143             if (obs->time[ir2] == obs->time[ir]) {
03144                 z[nz] = obs2->vpz[ir2];
03145                 for (id = 0; id < ctl->nd; id++) {
03146                     rad[id][nz] = obs2->rad[id][ir2];
03147                     tau[id][nz] = obs2->tau[id][ir2];
03148                 }
03149                 nz++;
03150             }
03151         if (nz < 2)
03152             ERRMSG("Cannot apply FOV convolution!");
03153
03154         /* Convolute profiles with FOV... */
03155         wsum = 0;
03156         for (id = 0; id < ctl->nd; id++) {
03157             obs->rad[id][ir] = 0;
03158             obs->tau[id][ir] = 0;
03159         }
03160         for (i = 0; i < n; i++) {
03161             zfov = obs->vpz[ir] + dz[i];
03162             idx = locate_irr(z, nz, zfov);
03163             for (id = 0; id < ctl->nd; id++) {
03164                 obs->rad[id][ir] += w[i]
03165                     * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03166                 obs->tau[id][ir] += w[i]
03167                     * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03168             }
03169             wsum += w[i];
03170         }
03171         for (id = 0; id < ctl->nd; id++) {
03172             obs->rad[id][ir] /= wsum;
03173             obs->tau[id][ir] /= wsum;
03174         }
03175     }
03176
03177     /* Free... */
03178     free(obs2);
03179 }

```

Here is the call graph for this function:



#### 5.15.2.16 void formod\_pencil ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, int *ir* )

Compute radiative transfer for a pencil beam.

Definition at line 3183 of file [jurassic.c](#).

```

03187     {
03188
03189     static tbl_t *tbl;
03190
03191     static int init = 0;
03192
03193     los_t *los;
03194
03195     double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197     int id, ip;
03198
03199     /* Initialize look-up tables... */
03200     if (!init) {
03201         init = 1;
03202         ALLOC(tbl, tbl_t, 1);
03203         init_tbl(ctl, tbl);
03204     }
03205
03206     /* Allocate... */
03207     ALLOC(los, los_t, 1);
03208
03209     /* Initialize... */
03210     for (id = 0; id < ctl->nd; id++) {
03211         obs->rad[id][ir] = 0;
03212         obs->tau[id][ir] = 1;
03213     }
03214
03215     /* Raytracing... */
03216     raytrace(ctl, atm, obs, los, ir);
03217
03218     /* Loop over LOS points... */
03219     for (ip = 0; ip < los->np; ip++) {
03220
03221         /* Get trace gas transmittance... */
03222         intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224         /* Get continuum absorption... */
03225         formod_continua(ctl, los, ip, beta_ctm);
03226
03227         /* Compute Planck function... */
03228         formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230         /* Loop over channels... */
03231         for (id = 0; id < ctl->nd; id++)
03232             if (tau_gas[id] > 0) {
03233

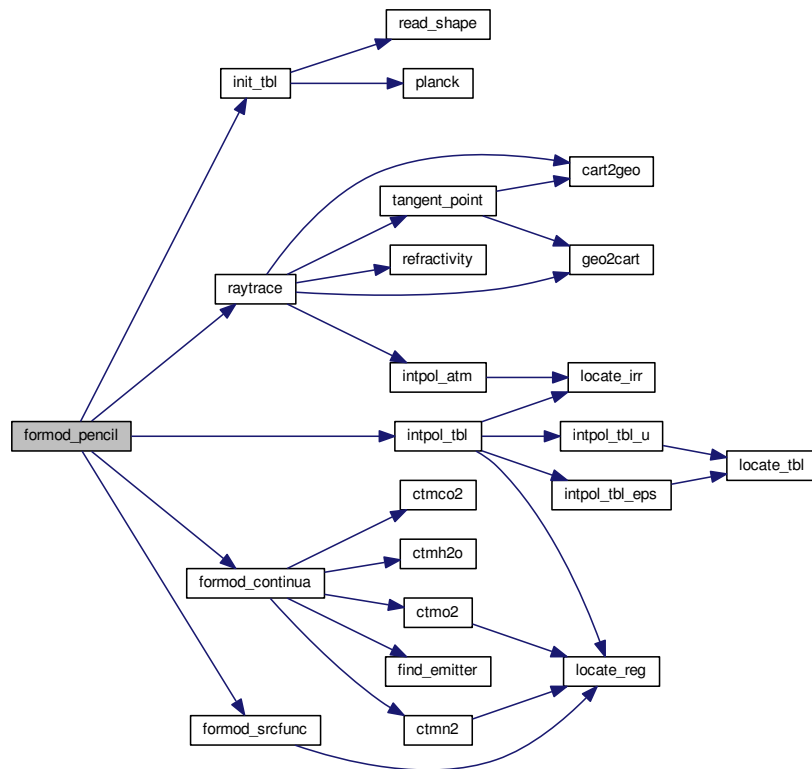
```

```

03234      /* Get segment emissivity... */
03235      eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237      /* Compute radiance... */
03238      obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240      /* Compute path transmittance... */
03241      obs->tau[id][ir] *= (1 - eps);
03242  }
03243  }
03244
03245  /* Add surface... */
03246  if (los->tsurf > 0) {
03247      formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248      for (id = 0; id < ctl->nd; id++)
03249          obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250  }
03251
03252  /* Free... */
03253  free(los);
03254  }

```

Here is the call graph for this function:



#### 5.15.2.17 void formod\_srcfunc ( ctl\_t \* ctl, tbl\_t \* tbl, double t, double \* src )

Compute Planck source function.

Definition at line 3258 of file [jurassic.c](#).

```

03262      {
03263
03264      int id, it;

```



```

03265
03266  /* Determine index in temperature array... */
03267  it = locate_reg(tbl->st, TBLNS, t);
03268
03269  /* Interpolate Planck function value... */
03270  for (id = 0; id < ctl->nd; id++)
03271      src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                  tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }

```

Here is the call graph for this function:



#### 5.15.2.18 void geo2cart ( double z, double lon, double lat, double \* x )

Convert geolocation to Cartesian coordinates.

Definition at line 3277 of file [jurassic.c](#).

```

03281      {
03282
03283      double radius;
03284
03285      radius = z + RE;
03286      x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287      x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288      x[2] = radius * sin(lat / 180 * M_PI);
03289 }

```

#### 5.15.2.19 void hydrostatic ( ctl\_t \* ctl, atm\_t \* atm )

Set hydrostatic equilibrium.

Definition at line 3293 of file [jurassic.c](#).

```

03295      {
03296
03297      static int ig_h2o = -999;
03298
03299      double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301      int i, ip, ipref = 0, ipt = 20;
03302
03303      /* Check reference height... */
03304      if (ctl->hydz < 0)
03305          return;
03306
03307      /* Determine emitter index of H2O... */
03308      if (ig_h2o == -999)
03309          ig_h2o = find_emitter(ctl, "H2O");
03310
03311      /* Find air parcel next to reference height... */
03312      for (ip = 0; ip < atm->np; ip++)
03313          if (fabs(atm->z[ip] - ctl->hydz) < dzmin) {
03314              dzmin = fabs(atm->z[ip] - ctl->hydz);
03315              ipref = ip;
03316          }

```

```

03317
03318 /* Upper part of profile... */
03319 for (ip = ipref + 1; ip < atm->np; ip++) {
03320     mean = 0;
03321     for (i = 0; i < ipt; i++) {
03322         if (ig_h2o >= 0)
03323             e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                     ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03325         mean += (e * mmh2o + (1 - e) * mmair)
03326             * G0 / RI
03327             / LIN(0.0, atm->t[ip - 1], ipt - 1.0, atm->t[ip], (double) i) / ipt;
03328     }
03329
03330 /* Compute p(z,T)... */
03331 atm->p[ip] =
03332     exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333 }
03334
03335 /* Lower part of profile... */
03336 for (ip = ipref - 1; ip >= 0; ip--) {
03337     mean = 0;
03338     for (i = 0; i < ipt; i++) {
03339         if (ig_h2o >= 0)
03340             e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                     ipt - 1.0, atm->q[ig_h2o][ip], (double) i);
03342         mean += (e * mmh2o + (1 - e) * mmair)
03343             * G0 / RI
03344             / LIN(0.0, atm->t[ip + 1], ipt - 1.0, atm->t[ip], (double) i) / ipt;
03345     }
03346
03347 /* Compute p(z,T)... */
03348 atm->p[ip] =
03349     exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350 }
03351 }

```

Here is the call graph for this function:



#### 5.15.2.20 void idx2name( ctl\_t \*ctl, int idx, char \*quantity )

Determine name of state vector quantity for given index.

Definition at line 3355 of file [jurassic.c](#).

```

03358 {
03359     int ig, iw;
03360
03361     if (idx == IDXP)
03362         sprintf(quantity, "PRESSURE");
03363
03364     if (idx == IDXT)
03365         sprintf(quantity, "TEMPERATURE");
03366
03367     for (ig = 0; ig < ctl->ng; ig++)
03368         if (idx == IDXQ(ig))
03369             sprintf(quantity, "%s", ctl->emitter[ig]);
03370
03371     for (iw = 0; iw < ctl->nw; iw++)
03372         if (idx == IDXK(iw))
03373             sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03374 }
03375 }

```

### 5.15.2.21 void init\_tbl ( ctl\_t \* ctl, tbl\_t \* tbl )

Initialize look-up tables.

Definition at line 3379 of file [jurassic.c](#).

```

03381         {
03382
03383     FILE *in;
03384
03385     char filename[2 * LEN], line[LEN];
03386
03387     double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388            f[NSHAPE], fsum, nu[NSHAPE];
03389
03390     int i, id, ig, ip, it, n;
03391
03392     /* Loop over trace gases and channels... */
03393     for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
03395                                press_old,temp,temp_old,u,u_old,id,ip,it)
03396     for (id = 0; id < ctl->nd; id++) {
03397
03398         /* Initialize... */
03399         tbl->np[ig][id] = -1;
03400         eps_old = -999;
03401         press_old = -999;
03402         temp_old = -999;
03403         u_old = -999;
03404
03405         /* Try to open file... */
03406         sprintf(filename, "%s%.4f%s.tab",
03407                ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03408         if (!(in = fopen(filename, "r"))) {
03409             printf("Missing emissivity table: %s\n", filename);
03410             continue;
03411         }
03412         printf("Read emissivity table: %s\n", filename);
03413
03414         /* Read data... */
03415         while (fgets(line, LEN, in)) {
03416
03417             /* Parse line... */
03418             if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03419                 continue;
03420
03421             /* Determine pressure index... */
03422             if (press != press_old) {
03423                 press_old = press;
03424                 if ((++tbl->np[ig][id]) >= TBLNP)
03425                     ERRMSG("Too many pressure levels!");
03426                 tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03427             }
03428
03429             /* Determine temperature index... */
03430             if (temp != temp_old) {
03431                 temp_old = temp;
03432                 if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03433                     ERRMSG("Too many temperatures!");
03434                 tbl->nu[ig][id][tbl->np[ig][id]]
03435                     [tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03436             }
03437
03438             /* Determine column density index... */
03439             if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03440                 [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03441                 eps_old = eps;
03442                 u_old = u;
03443                 if ((++tbl->nu[ig][id][tbl->np[ig][id]]
03444                     [tbl->nt[ig][id][tbl->np[ig][id]]]) >= TBLNU) {
03445                     tbl->nu[ig][id][tbl->np[ig][id]]
03446                         [tbl->nt[ig][id][tbl->np[ig][id]]]--;
03447                     continue;
03448                 }
03449             }
03450
03451             /* Store data... */
03452             tbl->p[ig][id][tbl->np[ig][id]] = press;
03453             tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03454                 = temp;
03455             tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03456                 [tbl->nu[ig][id][tbl->np[ig][id]]]
03457                 [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) u;

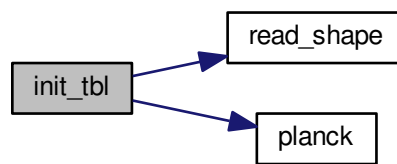
```

```

03457         tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458         [tbl->nu[ig][id][tbl->np[ig][id]]]
03459         [tbl->nt[ig][id][tbl->np[ig][id]]] = (float) eps;
03460     }
03461
03462     /* Increment counters... */
03463     tbl->np[ig][id]++;
03464     for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465         tbl->nt[ig][id][ip]++;
03466         for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467             tbl->nu[ig][id][ip][it]++;
03468     }
03469
03470     /* Close file... */
03471     fclose(in);
03472 }
03473
03474 /* Write info... */
03475 printf("Initialize source function table...\n");
03476
03477 /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479 for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488         /* Set temperature... */
03489         tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491         /* Integrate Planck function... */
03492         fsum = 0;
03493         tbl->sr[id][it] = 0;
03494         for (i = 0; i < n; i++) {
03495             fsum += f[i];
03496             tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497         }
03498         tbl->sr[id][it] /= fsum;
03499     }
03500 }
03501 }

```

Here is the call graph for this function:



**5.15.2.22** void `intpol_atm ( ctl_t * ctl, atm_t * atm, double z, double * p, double * t, double * q, double * k )`

Interpolate atmospheric data.

Definition at line 3505 of file `jurassic.c`.

```

03512     {
03513
03514     int ig, ip, iw;
03515

```

```

03516  /* Get array index... */
03517  ip = locate_irr(atm->z, atm->np, z);
03518
03519  /* Interpolate... */
03520  *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521  *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522  for (ig = 0; ig < ctl->ng; ig++)
03523      q[ig] =
03524          LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525  for (iw = 0; iw < ctl->nw; iw++)
03526      k[iw] =
03527          LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528  }

```

Here is the call graph for this function:



**5.15.2.23** void `intpol_tbl` ( `ctl_t` \* `ctl`, `tbl_t` \* `tbl`, `los_t` \* `los`, int `ip`, double `tau_path`[`NG`][`ND`], double `tau_seg`[`ND`] )

Get transmittance from look-up tables.

Definition at line 3532 of file [jurassic.c](#).

```

03538      {
03539
03540      double eps, eps00, eps01, eps10, eps11, u;
03541
03542      int id, ig, ipr, it0, it1;
03543
03544      /* Initialize... */
03545      if (ip <= 0)
03546          for (ig = 0; ig < ctl->ng; ig++)
03547              for (id = 0; id < ctl->nd; id++)
03548                  tau_path[ig][id] = 1;
03549
03550      /* Loop over channels... */
03551      for (id = 0; id < ctl->nd; id++) {
03552
03553          /* Initialize... */
03554          tau_seg[id] = 1;
03555
03556          /* Loop over emitters.... */
03557          for (ig = 0; ig < ctl->ng; ig++) {
03558
03559              /* Check size of table (pressure)... */
03560              if (tbl->np[ig][id] < 2)
03561                  eps = 0;
03562
03563              /* Check transmittance... */
03564              else if (tau_path[ig][id] < 1e-9)
03565                  eps = 1;
03566
03567              /* Interpolate... */
03568              else {
03569
03570                  /* Determine pressure and temperature indices... */
03571                  ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572                  it0 =
03573                      locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
03574                          t[ip]);
03575                  it1 =
03576                      locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03577                          los->t[ip]);

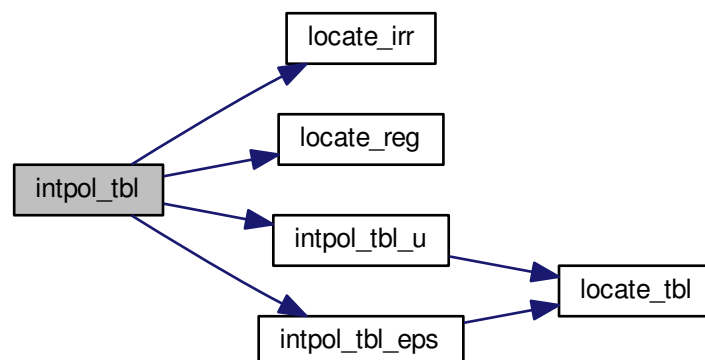
```

```

03577
03578 /* Check size of table (temperature and column density)... */
03579 if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03580     || tbl->nu[ig][id][ipr][it0] < 2
03581     || tbl->nu[ig][id][ipr][it0 + 1] < 2
03582     || tbl->nu[ig][id][ipr + 1][it1] < 2
03583     || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03584     eps = 0;
03585
03586 else {
03587
03588     /* Get emissivities of extended path... */
03589     u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590     eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592     u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593     eps01 =
03594         intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596     u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597     eps10 =
03598         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600     u =
03601         intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);
03602     eps11 =
03603         intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
03604 u[ig][ip]);
03605
03606     /* Interpolate with respect to temperature... */
03607     eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03608                 tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03609     eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03610                 tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03611
03612     /* Interpolate with respect to pressure... */
03613     eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03614                 tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03615
03616     /* Check emssivity range... */
03617     eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03618
03619     /* Determine segment emissivity... */
03620     eps = 1 - (1 - eps00) / tau_path[ig][id];
03621 }
03622
03623 /* Get transmittance of extended path... */
03624 tau_path[ig][id] *= (1 - eps);
03625
03626 /* Get segment transmittance... */
03627 tau_seg[id] *= (1 - eps);
03628 }
03629 }
03630 }

```

Here is the call graph for this function:



#### 5.15.2.24 double intpol\_tbl\_eps ( tbl\_t \* tbl, int ig, int id, int ip, int it, double u )

Interpolate emissivity from look-up tables.

Definition at line 3634 of file [jurassic.c](#).

```

03640         {
03641
03642     int idx;
03643
03644     /* Lower boundary... */
03645     if (u < tbl->u[ig][id][ip][it][0])
03646         return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647             u);
03648
03649     /* Upper boundary... */
03650     else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651         return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652             tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653             1e30, 1, u);
03654
03655     /* Interpolation... */
03656     else {
03657
03658         /* Get index... */
03659         idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661         /* Interpolate... */
03662         return
03663             LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664                 tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665                 u);
03666     }
03667 }

```

Here is the call graph for this function:



#### 5.15.2.25 double intpol\_tbl\_u ( tbl\_t \* tbl, int ig, int id, int ip, int it, double eps )

Interpolate column density from look-up tables.

Definition at line 3671 of file [jurassic.c](#).

```

03677         {
03678
03679     int idx;
03680
03681     /* Lower boundary... */
03682     if (eps < tbl->eps[ig][id][ip][it][0])
03683         return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684             eps);
03685
03686     /* Upper boundary... */
03687     else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03688         return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689             tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690             1, 1e30, eps);
03691

```

```

03692  /* Interpolation... */
03693  else {
03694
03695      /* Get index... */
03696      idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698      /* Interpolate... */
03699      return
03700      LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701         tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702         eps);
03703  }
03704 }

```

Here is the call graph for this function:



**5.15.2.26** void jsec2time ( double *jsec*, int \* *year*, int \* *mon*, int \* *day*, int \* *hour*, int \* *min*, int \* *sec*, double \* *remain* )

Convert seconds to date.

Definition at line 3708 of file [jurassic.c](#).

```

03716      {
03717
03718      struct tm t0, *t1;
03719
03720      time_t jsec0;
03721
03722      t0.tm_year = 100;
03723      t0.tm_mon = 0;
03724      t0.tm_mday = 1;
03725      t0.tm_hour = 0;
03726      t0.tm_min = 0;
03727      t0.tm_sec = 0;
03728
03729      jsec0 = (time_t) jsec + timegm(&t0);
03730      t1 = gmtime(&jsec0);
03731
03732      *year = t1->tm_year + 1900;
03733      *mon = t1->tm_mon + 1;
03734      *day = t1->tm_mday;
03735      *hour = t1->tm_hour;
03736      *min = t1->tm_min;
03737      *sec = t1->tm_sec;
03738      *remain = jsec - floor(jsec);
03739  }

```

**5.15.2.27** void kernel ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, gsl\_matrix \* *k* )

Compute Jacobians.

Definition at line 3743 of file [jurassic.c](#).

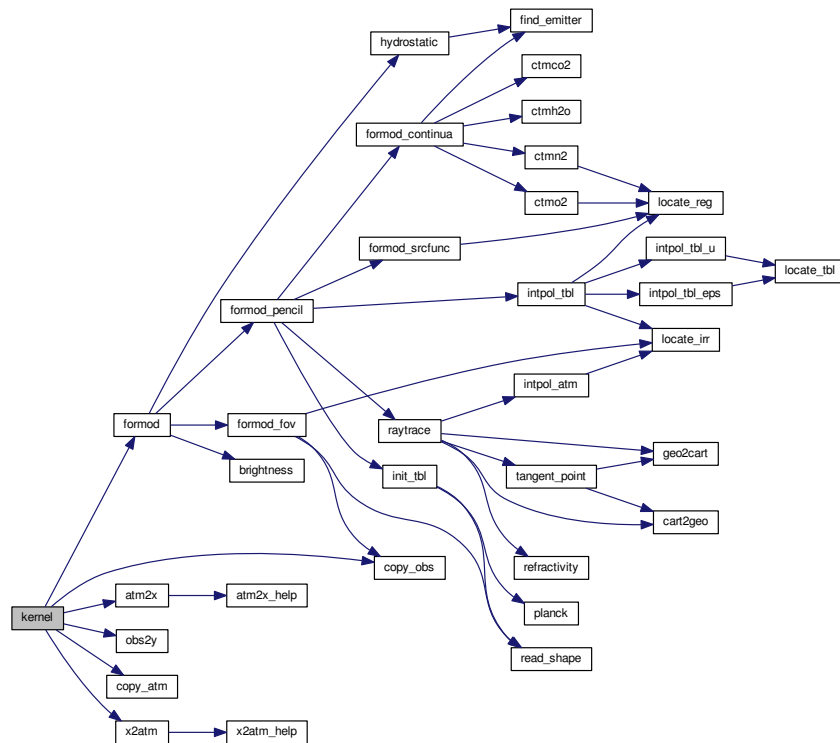


```

03747         {
03748
03749     atm_t *atml;
03750     obs_t *obs1;
03751
03752     gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754     int *iqa, j;
03755
03756     double h;
03757
03758     size_t i, n, m;
03759
03760     /* Get sizes... */
03761     m = k->size1;
03762     n = k->size2;
03763
03764     /* Allocate... */
03765     x0 = gsl_vector_alloc(n);
03766     yy0 = gsl_vector_alloc(m);
03767     ALLOC(iqa, int,
03768           N);
03769
03770     /* Compute radiance for undisturbed atmospheric data... */
03771     formod(ctl, atm, obs);
03772
03773     /* Compose vectors... */
03774     atm2x(ctl, atm, x0, iqa, NULL);
03775     obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777     /* Initialize kernel matrix... */
03778     gsl_matrix_set_zero(k);
03779
03780     /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atml,
03782     obs1)
03783     for (j = 0; j < (int) n; j++) {
03784
03785         /* Allocate... */
03786         x1 = gsl_vector_alloc(n);
03787         yy1 = gsl_vector_alloc(m);
03788         ALLOC(atml, atm_t, 1);
03789         ALLOC(obs1, obs_t, 1);
03790
03791         /* Set perturbation size... */
03792         if (iqa[j] == IDXP)
03793             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03794         else if (iqa[j] == IDXT)
03795             h = 1;
03796         else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03797             h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03798         else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03799             h = 1e-4;
03800         else
03801             ERRMSG("Cannot set perturbation size!");
03802
03803         /* Disturb state vector element... */
03804         gsl_vector_memcpy(x1, x0);
03805         gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03806         copy_atm(ctl, atml, atm, 0);
03807         copy_obs(ctl, obs1, obs, 0);
03808         x2atm(ctl, x1, atml);
03809
03810         /* Compute radiance for disturbed atmospheric data... */
03811         formod(ctl, atml, obs1);
03812
03813         /* Compose measurement vector for disturbed radiance data... */
03814         obs2y(ctl, obs1, yy1, NULL, NULL);
03815
03816         /* Compute derivatives... */
03817         for (i = 0; i < m; i++)
03818             gsl_matrix_set(k, i, (size_t) j,
03819                           (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03820
03821         /* Free... */
03822         gsl_vector_free(x1);
03823         gsl_vector_free(yy1);
03824         free(atml);
03825         free(obs1);
03826     }
03827
03828     /* Free... */
03829     gsl_vector_free(x0);
03830     gsl_vector_free(yy0);
03831     free(iqa);
03832 }

```

Here is the call graph for this function:



#### 5.15.2.28 int locate\_irr ( double \* xx, int n, double x )

Find array index for irregular grid.

Definition at line 3835 of file [jurassic.c](#).

```

03838     {
03839
03840     int i, ilo, ihi;
03841
03842     ilo = 0;
03843     ihi = n - 1;
03844     i = (ihi + ilo) >> 1;
03845
03846     if (xx[i] < xx[i + 1])
03847         while (ihi > ilo + 1) {
03848             i = (ihi + ilo) >> 1;
03849             if (xx[i] > x)
03850                 ihi = i;
03851             else
03852                 ilo = i;
03853         } else
03854             while (ihi > ilo + 1) {
03855                 i = (ihi + ilo) >> 1;
03856                 if (xx[i] <= x)
03857                     ihi = i;
03858                 else
03859                     ilo = i;
03860             }
03861     return ilo;
03862 }
03863 }
```

### 5.15.2.29 int locate\_reg ( double \* xx, int n, double x )

Find array index for regular grid.

Definition at line 3867 of file [jurassic.c](#).

```

03870         {
03871
03872     int i;
03873
03874     /* Calculate index... */
03875     i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877     /* Check range... */
03878     if (i < 0)
03879         i = 0;
03880     else if (i >= n - 2)
03881         i = n - 2;
03882
03883     return i;
03884 }
```

### 5.15.2.30 int locate\_tbl ( float \* xx, int n, double x )

Find array index in float array.

Definition at line 3888 of file [jurassic.c](#).

```

03891         {
03892
03893     int i, ilo, ihi;
03894
03895     ilo = 0;
03896     ihi = n - 1;
03897     i = (ihi + ilo) >> 1;
03898
03899     while (ihi > ilo + 1) {
03900         i = (ihi + ilo) >> 1;
03901         if (xx[i] > x)
03902             ihi = i;
03903         else
03904             ilo = i;
03905     }
03906
03907     return ilo;
03908 }
```

### 5.15.2.31 size\_t obs2y ( ctl\_t \* ctl, obs\_t \* obs, gsl\_vector \* y, int \* ida, int \* ira )

Compose measurement vector.

Definition at line 3912 of file [jurassic.c](#).

```

03917         {
03918
03919     int id, ir;
03920
03921     size_t m = 0;
03922
03923     /* Determine measurement vector... */
03924     for (ir = 0; ir < obs->nr; ir++)
03925         for (id = 0; id < ctl->nd; id++)
03926             if (gsl_finite(obs->rad[id][ir])) {
03927                 if (y != NULL)
03928                     gsl_vector_set(y, m, obs->rad[id][ir]);
03929                 if (ida != NULL)
03930                     ida[m] = id;
03931                 if (ira != NULL)
03932                     ira[m] = ir;
03933                 m++;
03934             }
03935
03936     return m;
03937 }
```

5.15.2.32 double planck ( double *t*, double *nu* )

Compute Planck function.

Definition at line 3941 of file [jurassic.c](#).

```
03943     {
03944
03945     return C1 * POW3(nu) / gsl_expml(C2 * nu / t);
03946 }
```

5.15.2.33 void raytrace ( ctl\_t \* *ctl*, atm\_t \* *atm*, obs\_t \* *obs*, los\_t \* *los*, int *ir* )

Do ray-tracing to determine LOS.

Definition at line 3950 of file [jurassic.c](#).

```
03955     {
03956
03957     double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958     lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959     xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961     int i, ig, ip, iw, stop = 0;
03962
03963     /* Initialize... */
03964     los->np = 0;
03965     los->tsurf = -999;
03966     obs->tpz[ir] = obs->vpz[ir];
03967     obs->tplon[ir] = obs->vplon[ir];
03968     obs->tplat[ir] = obs->vplat[ir];
03969
03970     /* Get altitude range of atmospheric data... */
03971     gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973     /* Check observer altitude... */
03974     if (obs->obsz[ir] < zmin)
03975         ERRMSG("Observer below surface!");
03976
03977     /* Check view point altitude... */
03978     if (obs->vpz[ir] > zmax)
03979         return;
03980
03981     /* Determine Cartesian coordinates for observer and view point... */
03982     geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983     geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985     /* Determine initial tangent vector... */
03986     for (i = 0; i < 3; i++)
03987         ex0[i] = xvp[i] - xobs[i];
03988     norm = NORM(ex0);
03989     for (i = 0; i < 3; i++)
03990         ex0[i] /= norm;
03991
03992     /* Observer within atmosphere... */
03993     for (i = 0; i < 3; i++)
03994         x[i] = xobs[i];
03995
03996     /* Observer above atmosphere (search entry point)... */
03997     if (obs->obsz[ir] > zmax) {
03998         dmax = norm;
03999         while (fabs(dmin - dmax) > 0.001) {
04000             d = (dmax + dmin) / 2;
04001             for (i = 0; i < 3; i++)
04002                 x[i] = xobs[i] + d * ex0[i];
04003             cart2geo(x, &z, &lon, &lat);
04004             if (z <= zmax && z > zmax - 0.001)
04005                 break;
04006             if (z < zmax - 0.0005)
04007                 dmax = d;
04008             else
04009                 dmin = d;
04010         }
04011     }
04012
04013     /* Ray-tracing... */
```

```

04014 while (1) {
04015
04016     /* Set step length... */
04017     ds = ctl->rayds;
04018     if (ctl->raydz > 0) {
04019         norm = NORM(x);
04020         for (i = 0; i < 3; i++)
04021             xh[i] = x[i] / norm;
04022         cosa = fabs(DOTP(ex0, xh));
04023         if (cosa != 0)
04024             ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025     }
04026
04027     /* Determine geolocation... */
04028     cart2geo(x, &z, &lon, &lat);
04029
04030     /* Check if LOS hits the ground or has left atmosphere... */
04031     if (z < zmin || z > zmax) {
04032         stop = (z < zmin ? 2 : 1);
04033         frac =
04034             ((z <
04035              zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                           1]);
04037         geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038                 los->lat[los->np - 1], xh);
04039         for (i = 0; i < 3; i++)
04040             x[i] = xh[i] + frac * (x[i] - xh[i]);
04041         cart2geo(x, &z, &lon, &lat);
04042         los->ds[los->np - 1] = ds * frac;
04043         ds = 0;
04044     }
04045
04046     /* Interpolate atmospheric data... */
04047     intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049     /* Save data... */
04050     los->lon[los->np] = lon;
04051     los->lat[los->np] = lat;
04052     los->z[los->np] = z;
04053     los->p[los->np] = p;
04054     los->t[los->np] = t;
04055     for (ig = 0; ig < ctl->ng; ig++)
04056         los->q[ig][los->np] = q[ig];
04057     for (iw = 0; iw < ctl->nw; iw++)
04058         los->k[iw][los->np] = k[iw];
04059     los->ds[los->np] = ds;
04060
04061     /* Increment and check number of LOS points... */
04062     if ((++los->np) > NLOS)
04063         ERRMSG("Too many LOS points!");
04064
04065     /* Check stop flag... */
04066     if (stop) {
04067         los->tsurf = (stop == 2 ? t : -999);
04068         break;
04069     }
04070
04071     /* Determine refractivity... */
04072     if (ctl->refrac && z <= zrefrac)
04073         n = 1 + refractivity(p, t);
04074     else
04075         n = 1;
04076
04077     /* Construct new tangent vector (first term)... */
04078     for (i = 0; i < 3; i++)
04079         exl[i] = ex0[i] * n;
04080
04081     /* Compute gradient of refractivity... */
04082     if (ctl->refrac && z <= zrefrac) {
04083         for (i = 0; i < 3; i++)
04084             xh[i] = x[i] + 0.5 * ds * ex0[i];
04085         cart2geo(xh, &z, &lon, &lat);
04086         intpol_atm(ctl, atm, z, &p, &t, q, k);
04087         n = refractivity(p, t);
04088         for (i = 0; i < 3; i++) {
04089             xh[i] += h;
04090             cart2geo(xh, &z, &lon, &lat);
04091             intpol_atm(ctl, atm, z, &p, &t, q, k);
04092             naux = refractivity(p, t);
04093             ng[i] = (naux - n) / h;
04094             xh[i] -= h;
04095         }
04096     } else
04097         for (i = 0; i < 3; i++)
04098             ng[i] = 0;
04099
04100     /* Construct new tangent vector (second term)... */

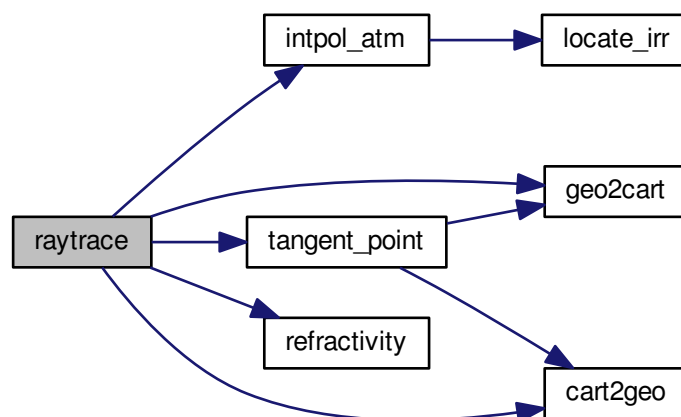
```

```

04101     for (i = 0; i < 3; i++)
04102         exl[i] += ds * ng[i];
04103
04104     /* Normalize new tangent vector... */
04105     norm = NORM(exl);
04106     for (i = 0; i < 3; i++)
04107         exl[i] /= norm;
04108
04109     /* Determine next point of LOS... */
04110     for (i = 0; i < 3; i++)
04111         x[i] += 0.5 * ds * (ex0[i] + exl[i]);
04112
04113     /* Copy tangent vector... */
04114     for (i = 0; i < 3; i++)
04115         ex0[i] = exl[i];
04116 }
04117
04118 /* Get tangent point (to be done before changing segment lengths!)... */
04119 tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
04120 tpplat[ir]);
04121
04122 /* Change segment lengths according to trapezoid rule... */
04123 for (ip = los->np - 1; ip >= 1; ip--)
04124     los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04125 los->ds[0] *= 0.5;
04126
04127 /* Compute column density... */
04128 for (ip = 0; ip < los->np; ip++)
04129     for (ig = 0; ig < ctl->ng; ig++)
04130         los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04131         / (KB * los->t[ip]) * los->ds[ip];
04132 }

```

Here is the call graph for this function:



#### 5.15.2.34 void read\_atm ( const char \* dirname, const char \* filename, ctl\_t \* ctl, atm\_t \* atm )

Read atmospheric data.

Definition at line 4135 of file [jurassic.c](#).

```

04139     {
04140
04141     FILE *in;
04142
04143     char file[LEN], line[LEN], *tok;

```

```

04144
04145     int ig, iw;
04146
04147     /* Init... */
04148     atm->np = 0;
04149
04150     /* Set filename... */
04151     if (dirname != NULL)
04152         sprintf(file, "%s/%s", dirname, filename);
04153     else
04154         sprintf(file, "%s", filename);
04155
04156     /* Write info... */
04157     printf("Read atmospheric data: %s\n", file);
04158
04159     /* Open file... */
04160     if (!(in = fopen(file, "r")))
04161         ERRMSG("Cannot open file!");
04162
04163     /* Read line... */
04164     while (fgets(line, LEN, in)) {
04165
04166         /* Read data... */
04167         TOK(line, tok, "%lg", atm->time[atm->np]);
04168         TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169         TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170         TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171         TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172         TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173         for (ig = 0; ig < ctl->ng; ig++)
04174             TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175         for (iw = 0; iw < ctl->nw; iw++)
04176             TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178         /* Increment data point counter... */
04179         if ((++atm->np) > NP)
04180             ERRMSG("Too many data points!");
04181     }
04182
04183     /* Close file... */
04184     fclose(in);
04185
04186     /* Check number of points... */
04187     if (atm->np < 1)
04188         ERRMSG("Could not read any data!");
04189 }

```

#### 5.15.2.35 void read\_ctl ( int argc, char \* argv[], ctl\_t \* ctl )

Read forward model control parameters.

Definition at line 4193 of file [jurassic.c](#).

```

04196     {
04197
04198     int id, ig, iw;
04199
04200     /* Write info... */
04201     printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202           "(executable: %s | compiled: %s, %s)\n\n",
04203           argv[0], __DATE__, __TIME__);
04204
04205     /* Emitters... */
04206     ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207     if (ctl->ng < 0 || ctl->ng > NG)
04208         ERRMSG("Set 0 <= NG <= MAX!");
04209     for (ig = 0; ig < ctl->ng; ig++)
04210         scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212     /* Radiance channels... */
04213     ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214     if (ctl->nd < 0 || ctl->nd > ND)
04215         ERRMSG("Set 0 <= ND <= MAX!");
04216     for (id = 0; id < ctl->nd; id++)
04217         ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219     /* Spectral windows... */
04220     ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221     if (ctl->nw < 0 || ctl->nw > NW)
04222         ERRMSG("Set 0 <= NW <= MAX!");

```

```

04223     for (id = 0; id < ctl->nd; id++)
04224         ctl->window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226     /* Emissivity look-up tables... */
04227     scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229     /* Hydrostatic equilibrium... */
04230     ctl->hydZ = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232     /* Continua... */
04233     ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234     ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235     ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236     ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238     /* Ray-tracing... */
04239     ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240     ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241     ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243     /* Field of view... */
04244     scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246     /* Retrieval interface... */
04247     ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248     ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249     ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250     ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251     for (ig = 0; ig < ctl->ng; ig++) {
04252         ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253         ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254     }
04255     for (iw = 0; iw < ctl->nw; iw++) {
04256         ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257         ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258     }
04259
04260     /* Output flags... */
04261     ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262     ctl->write_matrix =
04263         (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }

```

Here is the call graph for this function:



#### 5.15.2.36 void read\_matrix ( const char \* *dirname*, const char \* *filename*, gsl\_matrix \* *matrix* )

Read matrix.

Definition at line 4268 of file [jurassic.c](#).

```

04271     {
04272
04273     FILE *in;
04274
04275     char dum[LEN], file[LEN], line[LEN];
04276
04277     double value;
04278
04279     int i, j;
04280
04281     /* Set filename... */

```



```

04282     if (dirname != NULL)
04283         sprintf(file, "%s/%s", dirname, filename);
04284     else
04285         sprintf(file, "%s", filename);
04286
04287     /* Write info... */
04288     printf("Read matrix: %s\n", file);
04289
04290     /* Open file... */
04291     if (!(in = fopen(file, "r")))
04292         ERRMSG("Cannot open file!");
04293
04294     /* Read data... */
04295     gsl_matrix_set_zero(matrix);
04296     while (fgets(line, LEN, in))
04297         if (sscanf(line, "%d %s %s %s %s %s %d %s %s %s %s %s %lg",
04298             &i, dum, dum, dum, dum, dum,
04299             &j, dum, dum, dum, dum, dum, &value) == 13)
04300         gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302     /* Close file... */
04303     fclose(in);
04304 }

```

**5.15.2.37** void read\_obs ( const char \* *dirname*, const char \* *filename*, ctl\_t \* *ctl*, obs\_t \* *obs* )

Read observation data.

Definition at line 4308 of file [jurassic.c](#).

```

04312         {
04313
04314         FILE *in;
04315
04316         char file[LEN], line[LEN], *tok;
04317
04318         int id;
04319
04320         /* Init... */
04321         obs->nr = 0;
04322
04323         /* Set filename... */
04324         if (dirname != NULL)
04325             sprintf(file, "%s/%s", dirname, filename);
04326         else
04327             sprintf(file, "%s", filename);
04328
04329         /* Write info... */
04330         printf("Read observation data: %s\n", file);
04331
04332         /* Open file... */
04333         if (!(in = fopen(file, "r")))
04334             ERRMSG("Cannot open file!");
04335
04336         /* Read line... */
04337         while (fgets(line, LEN, in)) {
04338
04339             /* Read data... */
04340             TOK(line, tok, "%lg", obs->time[obs->nr]);
04341             TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342             TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343             TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344             TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345             TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346             TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347             TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348             TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349             TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350             for (id = 0; id < ctl->nd; id++)
04351                 TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352             for (id = 0; id < ctl->nd; id++)
04353                 TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355             /* Increment counter... */
04356             if ((++obs->nr) > NR)
04357                 ERRMSG("Too many rays!");
04358         }
04359
04360         /* Close file... */
04361         fclose(in);

```

```

04362
04363  /* Check number of points... */
04364  if (obs->nr < 1)
04365      ERRMSG("Could not read any data!");
04366  }

```

#### 5.15.2.38 void read\_shape ( const char \* filename, double \* x, double \* y, int \* n )

Read shape function.

Definition at line 4370 of file [jurassic.c](#).

```

04374      {
04375
04376      FILE *in;
04377
04378      char line[LEN];
04379
04380      /* Write info... */
04381      printf("Read shape function: %s\n", filename);
04382
04383      /* Open file... */
04384      if (!(in = fopen(filename, "r")))
04385          ERRMSG("Cannot open file!");
04386
04387      /* Read data... */
04388      *n = 0;
04389      while (fgets(line, LEN, in))
04390          if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391              if (++(*n) > NSHAPE)
04392                  ERRMSG("Too many data points!");
04393
04394      /* Check number of points... */
04395      if (*n < 1)
04396          ERRMSG("Could not read any data!");
04397
04398      /* Close file... */
04399      fclose(in);
04400  }

```

#### 5.15.2.39 double refractivity ( double p, double t )

Compute refractivity (return value is n - 1).

Definition at line 4404 of file [jurassic.c](#).

```

04406      {
04407
04408      /* Refractivity of air at 4 to 15 micron... */
04409      return 7.753e-05 * p / t;
04410  }

```

#### 5.15.2.40 double scan\_ctl ( int argc, char \* argv[], const char \* varname, int arridx, const char \* defvalue, char \* value )

Search control parameter file for variable entry.

Definition at line 4414 of file [jurassic.c](#).

```

04420         {
04421
04422     FILE *in = NULL;
04423
04424     char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425         msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427     int contain = 0, i;
04428
04429     /* Open file... */
04430     if (argv[1][0] != '-')
04431         if (!(in = fopen(argv[1], "r")))
04432             ERRMSG("Cannot open file!");
04433
04434     /* Set full variable name... */
04435     if (arridx >= 0) {
04436         sprintf(fullname1, "%s[%d]", varname, arridx);
04437         sprintf(fullname2, "%s[*]", varname);
04438     } else {
04439         sprintf(fullname1, "%s", varname);
04440         sprintf(fullname2, "%s", varname);
04441     }
04442
04443     /* Read data... */
04444     if (in != NULL)
04445         while (fgets(line, LEN, in))
04446             if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447                 if (strcasemp(rvarname, fullname1) == 0 ||
04448                     strcasemp(rvarname, fullname2) == 0) {
04449                     contain = 1;
04450                     break;
04451                 }
04452     for (i = 1; i < argc - 1; i++)
04453         if (strcasemp(argv[i], fullname1) == 0 ||
04454             strcasemp(argv[i], fullname2) == 0) {
04455             sprintf(rval, "%s", argv[i + 1]);
04456             contain = 1;
04457             break;
04458         }
04459
04460     /* Close file... */
04461     if (in != NULL)
04462         fclose(in);
04463
04464     /* Check for missing variables... */
04465     if (!contain) {
04466         if (strlen(defvalue) > 0)
04467             sprintf(rval, "%s", defvalue);
04468         else {
04469             sprintf(msg, "Missing variable %s!\n", fullname1);
04470             ERRMSG(msg);
04471         }
04472     }
04473
04474     /* Write info... */
04475     printf("%s = %s\n", fullname1, rval);
04476
04477     /* Return values... */
04478     if (value != NULL)
04479         sprintf(value, "%s", rval);
04480     return atof(rval);
04481 }

```

#### 5.15.2.41 void tangent\_point ( los\_t \* los, double \* tpz, double \* tplon, double \* tplat )

Find tangent point of a given LOS.

Definition at line 4485 of file [jurassic.c](#).

```

04489         {
04490
04491     double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493     size_t i, ip;
04494
04495     /* Find minimum altitude... */
04496     ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498     /* Nadir or zenith... */
04499     if (ip <= 0 || ip >= (size_t) los->np - 1) {

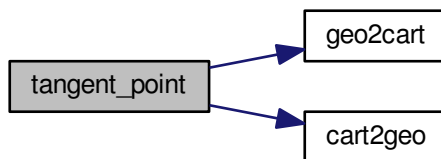
```

```

04500     *tpz = los->z[los->np - 1];
04501     *tplon = los->lon[los->np - 1];
04502     *tplat = los->lat[los->np - 1];
04503 }
04504
04505 /* Limb... */
04506 else {
04507
04508     /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509     yy0 = los->z[ip - 1];
04510     yy1 = los->z[ip];
04511     yy2 = los->z[ip + 1];
04512     x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513     x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514     a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515     b = -(yy0 - yy1) / x1 - a * x1;
04516     c = yy0;
04517
04518     /* Get tangent point location... */
04519     x = -b / (2 * a);
04520     *tpz = a * x * x + b * x + c;
04521     geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522     geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523     for (i = 0; i < 3; i++)
04524         v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525     cart2geo(v, &dummy, tplon, tplat);
04526 }
04527 }

```

Here is the call graph for this function:



#### 5.15.2.42 void time2jsec ( int year, int mon, int day, int hour, int min, int sec, double remain, double \* jsec )

Convert date to seconds.

Definition at line 4531 of file [jurassic.c](#).

```

04539     {
04540
04541     struct tm t0, t1;
04542
04543     t0.tm_year = 100;
04544     t0.tm_mon = 0;
04545     t0.tm_mday = 1;
04546     t0.tm_hour = 0;
04547     t0.tm_min = 0;
04548     t0.tm_sec = 0;
04549
04550     t1.tm_year = year - 1900;
04551     t1.tm_mon = mon - 1;
04552     t1.tm_mday = day;
04553     t1.tm_hour = hour;
04554     t1.tm_min = min;
04555     t1.tm_sec = sec;
04556
04557     *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }

```

#### 5.15.2.43 void timer ( const char \* name, const char \* file, const char \* func, int line, int mode )

Measure wall-clock time.

Definition at line 4562 of file [jurassic.c](#).

```

04567         {
04568
04569     static double w0[10];
04570
04571     static int l0[10], nt;
04572
04573     /* Start new timer... */
04574     if (mode == 1) {
04575         w0[nt] = omp_get_wtime();
04576         l0[nt] = line;
04577         if ((++nt) >= 10)
04578             ERRMSG("Too many timers!");
04579     }
04580
04581     /* Write elapsed time... */
04582     else {
04583
04584         /* Check timer index... */
04585         if (nt - 1 < 0)
04586             ERRMSG("Coding error!");
04587
04588         /* Write elapsed time... */
04589         printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590             name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591     }
04592
04593     /* Stop timer... */
04594     if (mode == 3)
04595         nt--;
04596 }

```

#### 5.15.2.44 void write\_atm ( const char \* dirname, const char \* filename, ctl\_t \* ctl, atm\_t \* atm )

Write atmospheric data.

Definition at line 4600 of file [jurassic.c](#).

```

04604         {
04605
04606     FILE *out;
04607
04608     char file[LEN];
04609
04610     int ig, ip, iw, n = 6;
04611
04612     /* Set filename... */
04613     if (dirname != NULL)
04614         sprintf(file, "%s/%s", dirname, filename);
04615     else
04616         sprintf(file, "%s", filename);
04617
04618     /* Write info... */
04619     printf("Write atmospheric data: %s\n", file);
04620
04621     /* Create file... */
04622     if (!(out = fopen(file, "w")))
04623         ERRMSG("Cannot create file!");
04624
04625     /* Write header... */
04626     fprintf(out,
04627         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628         "# $2 = altitude [km]\n"
04629         "# $3 = longitude [deg]\n"
04630         "# $4 = latitude [deg]\n"
04631         "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632     for (ig = 0; ig < ctl->ng; ig++)
04633         fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634     for (iw = 0; iw < ctl->nw; iw++)
04635         fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636 }

```

```

04637  /* Write data... */
04638  for (ip = 0; ip < atm->np; ip++) {
04639      if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640          || atm->lon[ip] != atm->lon[ip - 1])
04641          fprintf(out, "\n");
04642      fprintf(out, "%.2f %g %g %g %g", atm->time[ip], atm->z[ip],
04643          atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644      for (ig = 0; ig < ctl->ng; ig++)
04645          fprintf(out, " %g", atm->q[ig][ip]);
04646      for (iw = 0; iw < ctl->nw; iw++)
04647          fprintf(out, " %g", atm->k[iw][ip]);
04648      fprintf(out, "\n");
04649  }
04650
04651  /* Close file... */
04652  fclose(out);
04653 }

```

**5.15.2.45** `void write_matrix ( const char * dirname, const char * filename, ctl_t * ctl, gsl_matrix * matrix, atm_t * atm, obs_t * obs, const char * row_space, const char * col_space, const char * sort )`

Write matrix.

Definition at line 4657 of file [jurassic.c](#).

```

04666      {
04667
04668      FILE *out;
04669
04670      char file[LEN], quantity[LEN];
04671
04672      int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674      size_t i, j, nc, nr;
04675
04676      /* Check output flag... */
04677      if (!ctl->write_matrix)
04678          return;
04679
04680      /* Allocate... */
04681      ALLOC(cida, int, M);
04682      ALLOC(ciqa, int,
04683          N);
04684      ALLOC(cipa, int,
04685          N);
04686      ALLOC(cira, int,
04687          M);
04688      ALLOC(rida, int,
04689          M);
04690      ALLOC(riqa, int,
04691          N);
04692      ALLOC(ripa, int,
04693          N);
04694      ALLOC(rira, int,
04695          M);
04696
04697      /* Set filename... */
04698      if (dirname != NULL)
04699          sprintf(file, "%s/%s", dirname, filename);
04700      else
04701          sprintf(file, "%s", filename);
04702
04703      /* Write info... */
04704      printf("Write matrix: %s\n", file);
04705
04706      /* Create file... */
04707      if (!(out = fopen(file, "w")))
04708          ERRMSG("Cannot create file!");
04709
04710      /* Write header (row space)... */
04711      if (row_space[0] == 'y') {
04712
04713          fprintf(out,
04714              "# $1 = Row: index (measurement space)\n"
04715              "# $2 = Row: channel wavenumber [cm^-1]\n"
04716              "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04717              "# $4 = Row: view point altitude [km]\n"
04718              "# $5 = Row: view point longitude [deg]\n"
04719              "# $6 = Row: view point latitude [deg]\n");
04720

```

```

04721      /* Get number of rows... */
04722      nr = obs2y(ctl, obs, NULL, rida, rira);
04723
04724  } else {
04725
04726      fprintf(out,
04727              "# $1 = Row: index (state space)\n"
04728              "# $2 = Row: name of quantity\n"
04729              "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04730              "# $4 = Row: altitude [km]\n"
04731              "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733      /* Get number of rows... */
04734      nr = atm2x(ctl, atm, NULL, riq, ripa);
04735  }
04736
04737  /* Write header (column space)... */
04738  if (colspace[0] == 'y') {
04739
04740      fprintf(out,
04741              "# $7 = Col: index (measurement space)\n"
04742              "# $8 = Col: channel wavenumber [cm^-1]\n"
04743              "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04744              "# $10 = Col: view point altitude [km]\n"
04745              "# $11 = Col: view point longitude [deg]\n"
04746              "# $12 = Col: view point latitude [deg]\n");
04747
04748      /* Get number of columns... */
04749      nc = obs2y(ctl, obs, NULL, cida, cira);
04750
04751  } else {
04752
04753      fprintf(out,
04754              "# $7 = Col: index (state space)\n"
04755              "# $8 = Col: name of quantity\n"
04756              "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04757              "# $10 = Col: altitude [km]\n"
04758              "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04759
04760      /* Get number of columns... */
04761      nc = atm2x(ctl, atm, NULL, cira, cipa);
04762  }
04763
04764  /* Write header entry... */
04765  fprintf(out, "# $13 = Matrix element\n\n");
04766
04767  /* Write matrix data... */
04768  i = j = 0;
04769  while (i < nr && j < nc) {
04770
04771      /* Write info about the row... */
04772      if (rowspan[0] == 'y')
04773          fprintf(out, "%d %g %.2f %g %g %g",
04774                  (int) i, ctl->nu[rida[i]],
04775                  obs->time[rira[i]], obs->vpz[rira[i]],
04776                  obs->vplon[rira[i]], obs->vplat[rira[i]]);
04777      else {
04778          idx2name(ctl, riq[i], quantity);
04779          fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04780                  atm->time[ripa[i]], atm->z[ripa[i]],
04781                  atm->lon[ripa[i]], atm->lat[ripa[i]]);
04782      }
04783
04784      /* Write info about the column... */
04785      if (colspace[0] == 'y')
04786          fprintf(out, " %d %g %.2f %g %g %g",
04787                  (int) j, ctl->nu[cida[j]],
04788                  obs->time[cira[j]], obs->vpz[cira[j]],
04789                  obs->vplon[cira[j]], obs->vplat[cira[j]]);
04790      else {
04791          idx2name(ctl, cira[j], quantity);
04792          fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04793                  atm->time[cipa[j]], atm->z[cipa[j]],
04794                  atm->lon[cipa[j]], atm->lat[cipa[j]]);
04795      }
04796
04797      /* Write matrix entry... */
04798      fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04799
04800      /* Set matrix indices... */
04801      if (sort[0] == 'r') {
04802          j++;
04803          if (j >= nc) {
04804              j = 0;
04805              i++;
04806              fprintf(out, "\n");
04807          }
04808      }

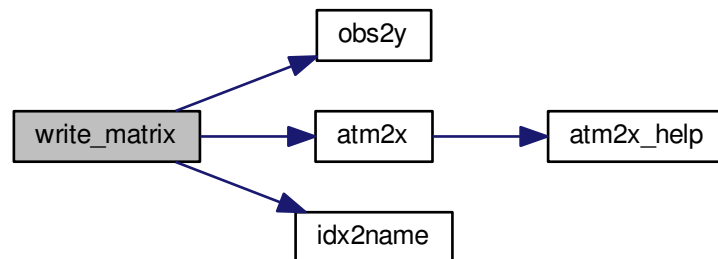
```

```

04808     } else {
04809         i++;
04810         if (i >= nr) {
04811             i = 0;
04812             j++;
04813             fprintf(out, "\n");
04814         }
04815     }
04816 }
04817
04818 /* Close file... */
04819 fclose(out);
04820
04821 /* Free... */
04822 free(cida);
04823 free(ciga);
04824 free(cipa);
04825 free(cira);
04826 free(rida);
04827 free(riqa);
04828 free(ripa);
04829 free(rira);
04830 }

```

Here is the call graph for this function:



#### 5.15.2.46 void write\_obs ( const char \* *dirname*, const char \* *filename*, *ctl\_t* \* *ctl*, *obs\_t* \* *obs* )

Write observation data.

Definition at line 4834 of file [jurassic.c](#).

```

04838     {
04839
04840         FILE *out;
04841
04842         char file[LEN];
04843
04844         int id, ir, n = 10;
04845
04846         /* Set filename... */
04847         if (dirname != NULL)
04848             sprintf(file, "%s/%s", dirname, filename);
04849         else
04850             sprintf(file, "%s", filename);
04851
04852         /* Write info... */
04853         printf("Write observation data: %s\n", file);
04854
04855         /* Create file... */
04856         if (!(out = fopen(file, "w")))
04857             ERRMSG("Cannot create file!");
04858

```



```

04859  /* Write header... */
04860  fprintf(out,
04861          "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862          "# $2 = observer altitude [km]\n"
04863          "# $3 = observer longitude [deg]\n"
04864          "# $4 = observer latitude [deg]\n"
04865          "# $5 = view point altitude [km]\n"
04866          "# $6 = view point longitude [deg]\n"
04867          "# $7 = view point latitude [deg]\n"
04868          "# $8 = tangent point altitude [km]\n"
04869          "# $9 = tangent point longitude [deg]\n"
04870          "# $10 = tangent point latitude [deg]\n");
04871  for (id = 0; id < ctl->nd; id++)
04872      fprintf(out, "# $d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873              ++n, ctl->nu[id]);
04874  for (id = 0; id < ctl->nd; id++)
04875      fprintf(out, "# $d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877  /* Write data... */
04878  for (ir = 0; ir < obs->nr; ir++) {
04879      if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880          fprintf(out, "\n");
04881      fprintf(out, "%.2f %g %g %g %g %g %g %g %g", obs->time[ir],
04882              obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883              obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884              obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885      for (id = 0; id < ctl->nd; id++)
04886          fprintf(out, " %g", obs->rad[id][ir]);
04887      for (id = 0; id < ctl->nd; id++)
04888          fprintf(out, " %g", obs->tau[id][ir]);
04889      fprintf(out, "\n");
04890  }
04891
04892  /* Close file... */
04893  fclose(out);
04894 }

```

#### 5.15.2.47 void x2atm ( ctl\_t \* *ctl*, gsl\_vector \* *x*, atm\_t \* *atm* )

Decompose parameter vector or state vector.

Definition at line 4898 of file [jurassic.c](#).

```

04901      {
04902
04903      int ig, iw;
04904
04905      size_t n = 0;
04906
04907      /* Set pressure... */
04908      x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
04909                  p, x, &n);
04909
04910      /* Set temperature... */
04911      x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
04912                  t, x, &n);
04912
04913      /* Set volume mixing ratio... */
04914      for (ig = 0; ig < ctl->ng; ig++)
04915          x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916                      atm->q[ig], x, &n);
04917
04918      /* Set extinction... */
04919      for (iw = 0; iw < ctl->nw; iw++)
04920          x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921                      atm->k[iw], x, &n);
04922 }

```

Here is the call graph for this function:



5.15.2.48 void x2atm\_help ( atm\_t \* atm, double zmin, double zmax, double \* value, gsl\_vector \* x, size\_t \* n )

Extract elements from state vector.

Definition at line 4926 of file jurassic.c.

```

04932         {
04933
04934     int ip;
04935
04936     /* Extract state vector elements... */
04937     for (ip = 0; ip < atm->np; ip++)
04938         if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939             value[ip] = gsl_vector_get(x, *n);
04940             (*n)++;
04941         }
04942 }
```

5.15.2.49 void y2obs ( ctl\_t \* ctl, gsl\_vector \* y, obs\_t \* obs )

Decompose measurement vector.

Definition at line 4946 of file jurassic.c.

```

04949         {
04950
04951     int id, ir;
04952
04953     size_t m = 0;
04954
04955     /* Decompose measurement vector... */
04956     for (ir = 0; ir < obs->nr; ir++)
04957         for (id = 0; id < ctl->nd; id++)
04958             if (gsl_finite(obs->rad[id][ir])) {
04959                 obs->rad[id][ir] = gsl_vector_get(y, m);
04960                 m++;
04961             }
04962 }
```

## 5.16 jurassic.h

```

00001 /*
00002  This file is part of JURASSIC.
00003
00004  JURASSIC is free software: you can redistribute it and/or modify
00005  it under the terms of the GNU General Public License as published by
00006  the Free Software Foundation, either version 3 of the License, or
00007  (at your option) any later version.
00008
00009  JURASSIC is distributed in the hope that it will be useful,
00010  but WITHOUT ANY WARRANTY; without even the implied warranty of
00011  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012  GNU General Public License for more details.
00013
00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00034 #include <gsl/gsl_math.h>
00035 #include <gsl/gsl_blas.h>
00036 #include <gsl/gsl_linalg.h>
00037 #include <gsl/gsl_statistics.h>
00038 #include <math.h>
00039 #include <omp.h>
00040 #include <stdio.h>
00041 #include <stdlib.h>
00042 #include <string.h>
00043 #include <time.h>
00044
00045 /* -----
```

```

00046     Macros...
00047     ----- */
00048
00050 #define ALLOC(ptr, type, n)
00051     if ((ptr=malloc((size_t) (n)*sizeof(type)))==NULL)
00052         ERRMSG("Out of memory!");
00053
00055 #define DIST(a, b) sqrt(DIST2(a, b))
00056
00058 #define DIST2(a, b)
00059     ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00060
00062 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00063
00065 #define ERRMSG(msg) {
00066     printf("\nError (%s, %s, %d): %s\n\n",
00067         __FILE__, __func__, __LINE__, msg);
00068     exit(EXIT_FAILURE);
00069 }
00070
00072 #define EXP(x0, y0, x1, y1, x)
00073     ((y0>0 && (y1>0)
00074      ? ((y0)*exp(log((y1)/(y0))/((x1)-(x0))*((x)-(x0))))
00075      : LIN(x0, y0, x1, y1, x))
00076
00078 #define LIN(x0, y0, x1, y1, x)
00079     ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00080
00082 #define NORM(a) sqrt(DOTP(a, a))
00083
00085 #define POW2(x) ((x)*(x))
00086
00088 #define POW3(x) ((x)*(x)*(x))
00089
00091 #define PRINT(format, var)
00092     printf("Print (%s, %s, %d): %s= "format"\n",
00093         __FILE__, __func__, __LINE__, #var, var);
00094
00096 #define TIMER(name, mode)
00097     {timer(name, __FILE__, __func__, __LINE__, mode);}
00098
00100 #define TOK(line, tok, format, var) {
00101     if(((tok)=strtok((line), " \t"))){
00102         if(sscanf(tok, format, &(var))!=1) continue;
00103     } else ERRMSG("Error while reading!");
00104 }
00105
00106 /* -----
00107     Constants...
00108     ----- */
00109
00111 #define TMIN 100.
00112
00114 #define TMAX 400.
00115
00117 #define C1 1.19104259e-8
00118
00120 #define C2 1.43877506
00121
00123 #define G0 9.80665
00124
00126 #define KB 1.3806504e-23
00127
00129 #define NA 6.02214199e23
00130
00132 #define P0 1013.25
00133
00135 #define T0 273.15
00136
00138 #define RE 6367.421
00139
00141 #define RI 8.3144598
00142
00144 #define ME 5.976e24
00145
00146 /* -----
00147     Dimensions...
00148     ----- */
00149
00151 #define ND 50
00152
00154 #define NG 20
00155
00157 #define NP 1000
00158
00160 #define NR 1000
00161

```

```

00163 #define NW 5
00164
00166 #define LEN 5000
00167
00169 #define M (NR*ND)
00170
00172 #define N (NQ*NP)
00173
00175 #define NQ (2+NG+NW)
00176
00178 #define NLOS 1000
00179
00181 #define NSHAPE 10000
00182
00184 #define NFOV 5
00185
00187 #define TBLNP 41
00188
00190 #define TBLNT 30
00191
00193 #define TBLNU 320
00194
00196 #define TBLNS 1200
00197
00198 /* -----
00199     Quantity indices...
00200     ----- */
00201
00203 #define IDXP 0
00204
00206 #define IDXT 1
00207
00209 #define IDXQ(ig) (2+ig)
00210
00212 #define IDXK(iw) (2+ctl->ng+iw)
00213
00214 /* -----
00215     Structs...
00216     ----- */
00217
00219 typedef struct {
00220
00222     int np;
00223
00225     double time[NP];
00226
00228     double z[NP];
00229
00231     double lon[NP];
00232
00234     double lat[NP];
00235
00237     double p[NP];
00238
00240     double t[NP];
00241
00243     double q[NG][NP];
00244
00246     double k[NW][NP];
00247
00248 } atm_t;
00249
00251 typedef struct {
00252
00254     int ng;
00255
00257     char emitter[NG][LEN];
00258
00260     int nd;
00261
00263     int nw;
00264
00266     double nu[ND];
00267
00269     int window[ND];
00270
00272     char tblbase[LEN];
00273
00275     double hyd;
00276
00278     int ctm_co2;
00279
00281     int ctm_h2o;
00282
00284     int ctm_n2;
00285
00287     int ctm_o2;

```

```
00288
00290     int  refrac;
00291
00293     double rayds;
00294
00296     double raydz;
00297
00299     char fov[LEN];
00300
00302     double retp_zmin;
00303
00305     double retp_zmax;
00306
00308     double rett_zmin;
00309
00311     double rett_zmax;
00312
00314     double retq_zmin[NG];
00315
00317     double retq_zmax[NG];
00318
00320     double retk_zmin[NW];
00321
00323     double retk_zmax[NW];
00324
00326     int  write_bbt;
00327
00329     int  write_matrix;
00330
00331 }   ctl_t;
00332
00334 typedef struct {
00335
00337     int  np;
00338
00340     double z[NLOS];
00341
00343     double lon[NLOS];
00344
00346     double lat[NLOS];
00347
00349     double p[NLOS];
00350
00352     double t[NLOS];
00353
00355     double q[NG][NLOS];
00356
00358     double k[NW][NLOS];
00359
00361     double tsurf;
00362
00364     double ds[NLOS];
00365
00367     double u[NG][NLOS];
00368
00369 }   los_t;
00370
00372 typedef struct {
00373
00375     int  nr;
00376
00378     double time[NR];
00379
00381     double obsz[NR];
00382
00384     double obslon[NR];
00385
00387     double obslat[NR];
00388
00390     double vpz[NR];
00391
00393     double vplon[NR];
00394
00396     double vplat[NR];
00397
00399     double tpz[NR];
00400
00402     double tplon[NR];
00403
00405     double tplat[NR];
00406
00408     double tau[ND][NR];
00409
00411     double rad[ND][NR];
00412
00413 }   obs_t;
00414
```

```

00416 typedef struct {
00417
00419     int np[NG][ND];
00420
00422     int nt[NG][ND][TBLNP];
00423
00425     int nu[NG][ND][TBLNP][TBLNT];
00426
00428     double p[NG][ND][TBLNP];
00429
00431     double t[NG][ND][TBLNP][TBLNT];
00432
00434     float u[NG][ND][TBLNP][TBLNT][TBLNU];
00435
00437     float eps[NG][ND][TBLNP][TBLNT][TBLNU];
00438
00440     double st[TBLNS];
00441
00443     double sr[ND][TBLNS];
00444
00445 } tbl_t;
00446
00447 /* -----
00448     Functions...
00449     ----- */
00450
00452 size_t atm2x(
00453     ctl_t * ctl,
00454     atm_t * atm,
00455     gsl_vector * x,
00456     int *iqa,
00457     int *ipa);
00458
00460 void atm2x_help(
00461     atm_t * atm,
00462     double zmin,
00463     double zmax,
00464     double *value,
00465     int val_iqa,
00466     gsl_vector * x,
00467     int *iqa,
00468     int *ipa,
00469     size_t * n);
00470
00472 double brightness(
00473     double rad,
00474     double nu);
00475
00477 void cart2geo(
00478     double *x,
00479     double *z,
00480     double *lon,
00481     double *lat);
00482
00484 void climatology(
00485     ctl_t * ctl,
00486     atm_t * atm_mean);
00487
00489 double ctmco2(
00490     double nu,
00491     double p,
00492     double t,
00493     double u);
00494
00496 double ctmh2o(
00497     double nu,
00498     double p,
00499     double t,
00500     double q,
00501     double u);
00502
00504 double ctmn2(
00505     double nu,
00506     double p,
00507     double t);
00508
00510 double ctmo2(
00511     double nu,
00512     double p,
00513     double t);
00514
00516 void copy_atm(
00517     ctl_t * ctl,
00518     atm_t * atm_dest,
00519     atm_t * atm_src,
00520     int init);
00521

```

```
00523 void copy_obs(  
00524     ctl_t * ctl,  
00525     obs_t * obs_dest,  
00526     obs_t * obs_src,  
00527     int init);  
00528  
00530 int find_emitter(  
00531     ctl_t * ctl,  
00532     const char *emitter);  
00533  
00535 void formod(  
00536     ctl_t * ctl,  
00537     atm_t * atm,  
00538     obs_t * obs);  
00539  
00541 void formod_continua(  
00542     ctl_t * ctl,  
00543     los_t * los,  
00544     int ip,  
00545     double *beta);  
00546  
00548 void formod_fov(  
00549     ctl_t * ctl,  
00550     obs_t * obs);  
00551  
00553 void formod_pencil(  
00554     ctl_t * ctl,  
00555     atm_t * atm,  
00556     obs_t * obs,  
00557     int ir);  
00558  
00560 void formod_srcfunc(  
00561     ctl_t * ctl,  
00562     tbl_t * tbl,  
00563     double t,  
00564     double *src);  
00565  
00567 void geo2cart(  
00568     double z,  
00569     double lon,  
00570     double lat,  
00571     double **);  
00572  
00574 void hydrostatic(  
00575     ctl_t * ctl,  
00576     atm_t * atm);  
00577  
00579 void idx2name(  
00580     ctl_t * ctl,  
00581     int idx,  
00582     char *quantity);  
00583  
00585 void init_tbl(  
00586     ctl_t * ctl,  
00587     tbl_t * tbl);  
00588  
00590 void intpol_atm(  
00591     ctl_t * ctl,  
00592     atm_t * atm,  
00593     double z,  
00594     double *p,  
00595     double *t,  
00596     double *q,  
00597     double *k);  
00598  
00600 void intpol_tbl(  
00601     ctl_t * ctl,  
00602     tbl_t * tbl,  
00603     los_t * los,  
00604     int ip,  
00605     double tau_path[NG][ND],  
00606     double tau_seg[ND]);  
00607  
00609 double intpol_tbl_eps(  
00610     tbl_t * tbl,  
00611     int ig,  
00612     int id,  
00613     int ip,  
00614     int it,  
00615     double u);  
00616  
00618 double intpol_tbl_u(  
00619     tbl_t * tbl,  
00620     int ig,  
00621     int id,  
00622     int ip,  
00623     int it,
```

```
00624     double eps);
00625
00627 void jsec2time(
00628     double jsec,
00629     int *year,
00630     int *mon,
00631     int *day,
00632     int *hour,
00633     int *min,
00634     int *sec,
00635     double *remain);
00636
00638 void kernel(
00639     ctl_t * ctl,
00640     atm_t * atm,
00641     obs_t * obs,
00642     gsl_matrix * k);
00643
00645 int locate_irr(
00646     double **xx,
00647     int n,
00648     double x);
00649
00651 int locate_reg(
00652     double **xx,
00653     int n,
00654     double x);
00655
00657 int locate_tbl(
00658     float **xx,
00659     int n,
00660     double x);
00661
00663 size_t obs2y(
00664     ctl_t * ctl,
00665     obs_t * obs,
00666     gsl_vector * y,
00667     int *ida,
00668     int *ira);
00669
00671 double planck(
00672     double t,
00673     double nu);
00674
00676 void raytrace(
00677     ctl_t * ctl,
00678     atm_t * atm,
00679     obs_t * obs,
00680     los_t * los,
00681     int ir);
00682
00684 void read_atm(
00685     const char *dirname,
00686     const char *filename,
00687     ctl_t * ctl,
00688     atm_t * atm);
00689
00691 void read_ctl(
00692     int argc,
00693     char *argv[],
00694     ctl_t * ctl);
00695
00697 void read_matrix(
00698     const char *dirname,
00699     const char *filename,
00700     gsl_matrix * matrix);
00701
00703 void read_obs(
00704     const char *dirname,
00705     const char *filename,
00706     ctl_t * ctl,
00707     obs_t * obs);
00708
00710 void read_shape(
00711     const char *filename,
00712     double *x,
00713     double *y,
00714     int *n);
00715
00717 double refractivity(
00718     double p,
00719     double t);
00720
00722 double scan_ctl(
00723     int argc,
00724     char *argv[],
00725     const char *varname,
```



```

00726     int arridx,
00727     const char *defvalue,
00728     char *value);
00729
00731 void tangent_point(
00732     los_t * los,
00733     double *tpz,
00734     double *tplon,
00735     double *tplat);
00736
00738 void time2jsec(
00739     int year,
00740     int mon,
00741     int day,
00742     int hour,
00743     int min,
00744     int sec,
00745     double remain,
00746     double *jsec);
00747
00749 void timer(
00750     const char *name,
00751     const char *file,
00752     const char *func,
00753     int line,
00754     int mode);
00755
00757 void write_atm(
00758     const char *dirname,
00759     const char *filename,
00760     ctl_t * ctl,
00761     atm_t * atm);
00762
00764 void write_matrix(
00765     const char *dirname,
00766     const char *filename,
00767     ctl_t * ctl,
00768     gsl_matrix * matrix,
00769     atm_t * atm,
00770     obs_t * obs,
00771     const char *rowsep,
00772     const char *colsep,
00773     const char *sort);
00774
00776 void write_obs(
00777     const char *dirname,
00778     const char *filename,
00779     ctl_t * ctl,
00780     obs_t * obs);
00781
00783 void x2atm(
00784     ctl_t * ctl,
00785     gsl_vector * x,
00786     atm_t * atm);
00787
00789 void x2atm_help(
00790     atm_t * atm,
00791     double zmin,
00792     double zmax,
00793     double *value,
00794     gsl_vector * x,
00795     size_t * n);
00796
00798 void y2obs(
00799     ctl_t * ctl,
00800     gsl_vector * y,
00801     obs_t * obs);

```

## 5.17 kernel.c File Reference

Calculate kernel functions.

### Functions

- int [main](#) (int argc, char \*argv[])

### 5.17.1 Detailed Description

Calculate kernel functions.

Definition in file [kernel.c](#).

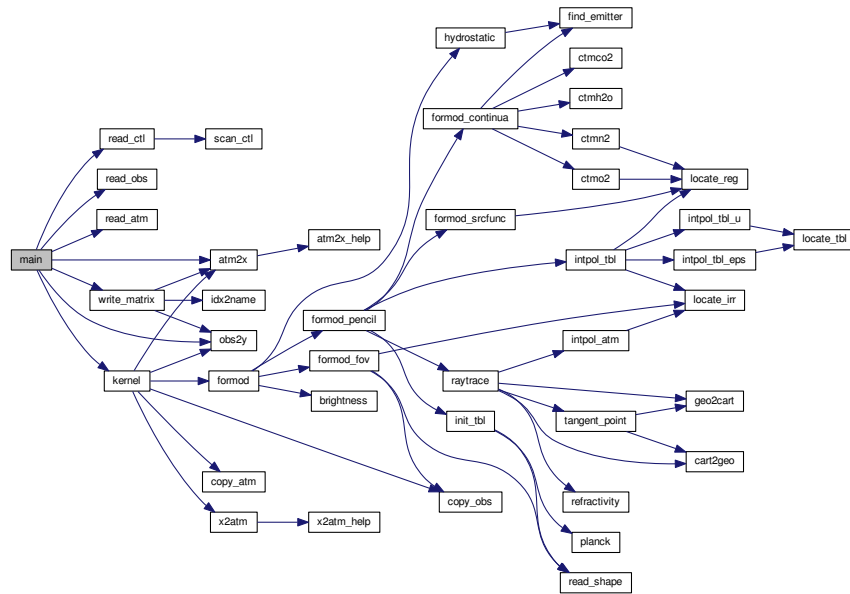
### 5.17.2 Function Documentation

#### 5.17.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file [kernel.c](#).

```
00029         {
00030
00031     static atm_t atm;
00032     static ctl_t ctl;
00033     static obs_t obs;
00034
00035     gsl_matrix *k;
00036
00037     size_t m, n;
00038
00039     /* Check arguments... */
00040     if (argc < 5)
00041         ERRMSG("Give parameters: <ctl> <obs> <atm> <kernel>");
00042
00043     /* Read control parameters... */
00044     read_ctl(argc, argv, &ctl);
00045
00046     /* Set flags... */
00047     ctl.write_matrix = 1;
00048
00049     /* Read observation geometry... */
00050     read_obs(NULL, argv[2], &ctl, &obs);
00051
00052     /* Read atmospheric data... */
00053     read_atm(NULL, argv[3], &ctl, &atm);
00054
00055     /* Get sizes... */
00056     n = atm2x(&ctl, &atm, NULL, NULL, NULL);
00057     m = obs2y(&ctl, &obs, NULL, NULL, NULL);
00058
00059     /* Check sizes... */
00060     if (n <= 0)
00061         ERRMSG("No state vector elements!");
00062     if (m <= 0)
00063         ERRMSG("No measurement vector elements!");
00064
00065     /* Allocate... */
00066     k = gsl_matrix_alloc(m, n);
00067
00068     /* Compute kernel matrix... */
00069     kernel(&ctl, &atm, &obs, k);
00070
00071     /* Write matrix to file... */
00072     write_matrix(NULL, argv[4], &ctl, k, &atm, &obs, "y", "x", "r");
00073
00074     /* Free... */
00075     gsl_matrix_free(k);
00076
00077     return EXIT_SUCCESS;
00078 }
```

Here is the call graph for this function:



## 5.18 kernel.c

```

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00012  GNU General Public License for more details.
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00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     static atm_t atm;
00032     static ctl_t ctl;
00033     static obs_t obs;
00034
00035     gsl_matrix *k;
00036
00037     size_t m, n;
00038
00039     /* Check arguments... */
00040     if (argc < 5)
00041         ERRMSG("Give parameters: <ctl> <obs> <atm> <kernel>");
00042
00043     /* Read control parameters... */
00044     read_ctl(argc, argv, &ctl);
00045
00046     /* Set flags... */
00047     ctl.write_matrix = 1;
00048
00049     /* Read observation geometry... */

```

```

00050  read_obs(NULL, argv[2], &ctl, &obs);
00051
00052  /* Read atmospheric data... */
00053  read_atm(NULL, argv[3], &ctl, &atm);
00054
00055  /* Get sizes... */
00056  n = atm2x(&ctl, &atm, NULL, NULL, NULL);
00057  m = obs2y(&ctl, &obs, NULL, NULL, NULL);
00058
00059  /* Check sizes... */
00060  if (n <= 0)
00061      ERRMSG("No state vector elements!");
00062  if (m <= 0)
00063      ERRMSG("No measurement vector elements!");
00064
00065  /* Allocate... */
00066  k = gsl_matrix_alloc(m, n);
00067
00068  /* Compute kernel matrix... */
00069  kernel(&ctl, &atm, &obs, k);
00070
00071  /* Write matrix to file... */
00072  write_matrix(NULL, argv[4], &ctl, k, &atm, &obs, "y", "x", "x");
00073
00074  /* Free... */
00075  gsl_matrix_free(k);
00076
00077  return EXIT_SUCCESS;
00078 }

```

## 5.19 limb.c File Reference

Create observation geometry for a limb sounder.

### Functions

- int [main](#) (int argc, char \*argv[])

#### 5.19.1 Detailed Description

Create observation geometry for a limb sounder.

Definition in file [limb.c](#).

#### 5.19.2 Function Documentation

##### 5.19.2.1 int main ( int argc, char \* argv[] )

Definition at line 27 of file [limb.c](#).

```

00029      {
00030
00031      static ctl_t ctl;
00032      static obs_t obs;
00033
00034      double dz, obsz, z, z0, z1;
00035
00036      /* Check arguments... */
00037      if (argc < 3)
00038          ERRMSG("Give parameters: <ctl> <obs>");
00039
00040      /* Read control parameters... */
00041      read_ctl(argc, argv, &ctl);
00042      obsz = scan_ctl(argc, argv, "OBSZ", -1, "780", NULL);
00043      z0 = scan_ctl(argc, argv, "Z0", -1, "6", NULL);

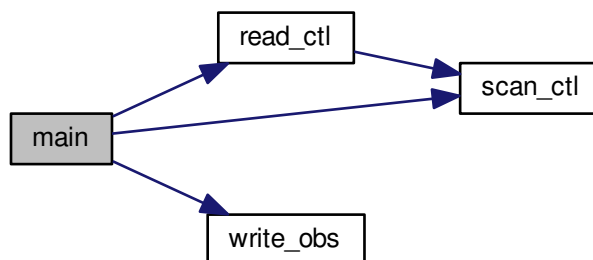
```

```

00044  z1 = scan_ctl(argc, argv, "Z1", -1, "70", NULL);
00045  dz = scan_ctl(argc, argv, "DZ", -1, "1.5", NULL);
00046
00047  /* Create measurement geometry... */
00048  for (z = z0; z <= z1; z += dz) {
00049      obs.obsz[obs.nr] = obsz;
00050      obs.vpz[obs.nr] = z;
00051      obs.vplat[obs.nr] = 180 / M_PI * acos((RE + z) / (RE + obsz));
00052      if ((++obs.nr) >= NR)
00053          ERRMSG("Too many rays!");
00054  }
00055
00056  /* Write observation data... */
00057  write_obs(NULL, argv[2], &ctl, &obs);
00058
00059  return EXIT_SUCCESS;
00060 }

```

Here is the call graph for this function:



## 5.20 limb.c

```

00001  /*
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00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018  */
00019
00025  #include "jurassic.h"
00026
00027  int main(
00028      int argc,
00029      char *argv[]) {
00030
00031      static ctl_t ctl;
00032      static obs_t obs;
00033
00034      double dz, obsz, z, z0, z1;
00035
00036      /* Check arguments... */
00037      if (argc < 3)
00038          ERRMSG("Give parameters: <ctl> <obs>");
00039

```

```

00040  /* Read control parameters... */
00041  read_ctl(argc, argv, &ctl);
00042  obsz = scan_ctl(argc, argv, "OBSZ", -1, "780", NULL);
00043  z0 = scan_ctl(argc, argv, "Z0", -1, "6", NULL);
00044  z1 = scan_ctl(argc, argv, "Z1", -1, "70", NULL);
00045  dz = scan_ctl(argc, argv, "DZ", -1, "1.5", NULL);
00046
00047  /* Create measurement geometry... */
00048  for (z = z0; z <= z1; z += dz) {
00049      obs.obsz[obs.nr] = obsz;
00050      obs.vpz[obs.nr] = z;
00051      obs.vplat[obs.nr] = 180 / M_PI * acos((RE + z) / (RE + obsz));
00052      if ((++obs.nr) >= NR)
00053          ERRMSG("Too many rays!");
00054  }
00055
00056  /* Write observation data... */
00057  write_obs(NULL, argv[2], &ctl, &obs);
00058
00059  return EXIT_SUCCESS;
00060 }

```

## 5.21 nadir.c File Reference

Create observation geometry for a nadir sounder.

### Functions

- [int main](#) (int argc, char \*argv[])

#### 5.21.1 Detailed Description

Create observation geometry for a nadir sounder.

Definition in file [nadir.c](#).

#### 5.21.2 Function Documentation

##### 5.21.2.1 int main ( int argc, char \* argv[] )

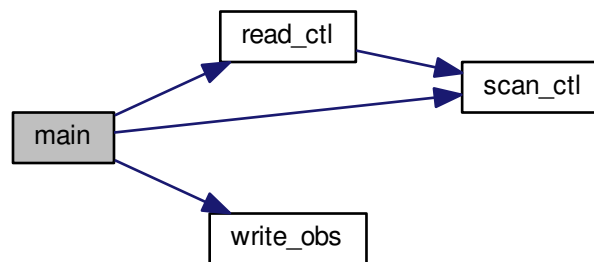
Definition at line 27 of file [nadir.c](#).

```

00029      {
00030
00031      static ctl_t ctl;
00032      static obs_t obs;
00033
00034      double dlat, lat, lat0, lat1, obsz;
00035
00036      /* Check arguments... */
00037      if (argc < 3)
00038          ERRMSG("Give parameters: <ctl> <obs>");
00039
00040      /* Read control parameters... */
00041      read_ctl(argc, argv, &ctl);
00042      obsz = scan_ctl(argc, argv, "OBSZ", -1, "700", NULL);
00043      lat0 = scan_ctl(argc, argv, "LAT0", -1, "-8.01", NULL);
00044      lat1 = scan_ctl(argc, argv, "LAT1", -1, "8.01", NULL);
00045      dlat = scan_ctl(argc, argv, "DLAT", -1, "0.18", NULL);
00046
00047      /* Create measurement geometry... */
00048      for (lat = lat0; lat <= lat1; lat += dlat) {
00049          obs.obsz[obs.nr] = obsz;
00050          obs.vplat[obs.nr] = lat;
00051          if ((++obs.nr) >= NR)
00052              ERRMSG("Too many rays!");
00053      }
00054
00055      /* Write observation data... */
00056      write_obs(NULL, argv[2], &ctl, &obs);
00057
00058      return EXIT_SUCCESS;
00059  }

```

Here is the call graph for this function:



## 5.22 nadir.c

```

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00012  GNU General Public License for more details.
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00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     static ctl_t ctl;
00032     static obs_t obs;
00033
00034     double dlat, lat, lat0, lat1, obsz;
00035
00036     /* Check arguments... */
00037     if (argc < 3)
00038         ERRMSG("Give parameters: <ctl> <obs>");
00039
00040     /* Read control parameters... */
00041     read_ctl(argc, argv, &ctl);
00042     obsz = scan_ctl(argc, argv, "OBSZ", -1, "700", NULL);
00043     lat0 = scan_ctl(argc, argv, "LAT0", -1, "-8.01", NULL);
00044     lat1 = scan_ctl(argc, argv, "LAT1", -1, "8.01", NULL);
00045     dlat = scan_ctl(argc, argv, "DLAT", -1, "0.18", NULL);
00046
00047     /* Create measurement geometry... */
00048     for (lat = lat0; lat <= lat1; lat += dlat) {
00049         obs.obsz[obs.nr] = obsz;
00050         obs.vplat[obs.nr] = lat;
00051         if ((++obs.nr) >= NR)
00052             ERRMSG("Too many rays!");
00053     }
00054
00055     /* Write observation data... */
00056     write_obs(NULL, argv[2], &ctl, &obs);
00057
00058     return EXIT_SUCCESS;
00059 }
  
```

## 5.23 `planck.c` File Reference

Convert brightness temperature to radiance.

### Functions

- `int main` (`int argc`, `char *argv[]`)

#### 5.23.1 Detailed Description

Convert brightness temperature to radiance.

Definition in file [planck.c](#).

#### 5.23.2 Function Documentation

##### 5.23.2.1 `int main ( int argc, char * argv[] )`

Definition at line 27 of file [planck.c](#).

```
00029         {
00030
00031     double nu, t;
00032
00033     /* Check arguments... */
00034     if (argc < 3)
00035         ERRMSG("Give parameters: <t> <nu>");
00036
00037     /* Read arguments... */
00038     t = atof(argv[1]);
00039     nu = atof(argv[2]);
00040
00041     /* Compute Planck function... */
00042     printf("%.10g\n", planck(t, nu));
00043
00044     return EXIT_SUCCESS;
00045 }
```

Here is the call graph for this function:





## 5.24 planck.c

```

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00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     double nu, t;
00032
00033     /* Check arguments... */
00034     if (argc < 3)
00035         ERRMSG("Give parameters: <t> <nu>");
00036
00037     /* Read arguments... */
00038     t = atof(argv[1]);
00039     nu = atof(argv[2]);
00040
00041     /* Compute Planck function... */
00042     printf("%.10g\n", planck(t, nu));
00043
00044     return EXIT_SUCCESS;
00045 }

```

## 5.25 raytrace.c File Reference

Determine atmospheric ray paths.

### Functions

- int `main` (int argc, char \*argv[])

### 5.25.1 Detailed Description

Determine atmospheric ray paths.

Definition in file `raytrace.c`.

## 5.25.2 Function Documentation

## 5.25.2.1 int main ( int argc, char \* argv[] )

Definition at line 27 of file [raytrace.c](#).

```

00029         {
00030
00031     static atm_t atm, atm2;
00032     static ctl_t ctl;
00033     static los_t los;
00034     static obs_t obs;
00035
00036     FILE *out;
00037
00038     char filename[LEN], losbase[LEN];
00039
00040     double u[NG], s;
00041
00042     int ig, ip, ir, iw;
00043
00044     /* Check arguments... */
00045     if (argc < 4)
00046         ERRMSG("Give parameters: <ctl> <obs> <atm>");
00047
00048     /* Read control parameters... */
00049     read_ctl(argc, argv, &ctl);
00050
00051     /* Get basenames... */
00052     scan_ctl(argc, argv, "LOSBASE", -1, "los", losbase);
00053
00054     /* Read observation geometry... */
00055     read_obs(NULL, argv[2], &ctl, &obs);
00056
00057     /* Read atmospheric data... */
00058     read_atm(NULL, argv[3], &ctl, &atm);
00059
00060     /* Write info... */
00061     printf("Write raytrace data: raytrace.tab\n");
00062
00063     /* Create file... */
00064     if (!(out = fopen("raytrace.tab", "w")))
00065         ERRMSG("Cannot create file!");
00066
00067     /* Write header... */
00068     fprintf(out,
00069         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
00070         "# $2 = observer altitude [km]\n"
00071         "# $3 = observer longitude [deg]\n"
00072         "# $4 = observer latitude [deg]\n"
00073         "# $5 = view point altitude [km]\n"
00074         "# $6 = view point longitude [deg]\n"
00075         "# $7 = view point latitude [deg]\n"
00076         "# $8 = tangent point altitude [km]\n"
00077         "# $9 = tangent point longitude [deg]\n"
00078         "# $10 = tangent point latitude [deg]\n"
00079         "# $11 = ray path index\n" "# $12 = ray path length [km]\n");
00080     for (ig = 0; ig < ctl.ng; ig++)
00081         fprintf(out, "# $12 = %s column density [molec/cm^2]\n",
00082             13 + ig, ctl.emitter[ig]);
00083     fprintf(out, "\n");
00084
00085     /* Loop over rays... */
00086     for (ir = 0; ir < obs.nr; ir++) {
00087
00088         /* Raytracing... */
00089         raytrace(&ctl, &atm, &obs, &los, ir);
00090
00091         /* Copy data... */
00092         atm2.np = los.np;
00093         for (ip = 0; ip < los.np; ip++) {
00094             atm2.time[ip] = obs.time[ir];
00095             atm2.z[ip] = los.z[ip];
00096             atm2.lon[ip] = los.lon[ip];
00097             atm2.lat[ip] = los.lat[ip];
00098             atm2.p[ip] = los.p[ip];
00099             atm2.t[ip] = los.t[ip];
00100             for (ig = 0; ig < ctl.ng; ig++)
00101                 atm2.q[ig][ip] = los.q[ig][ip];
00102             for (iw = 0; iw < ctl.nw; iw++)
00103                 atm2.k[iw][ip] = los.k[iw][ip];
00104         }

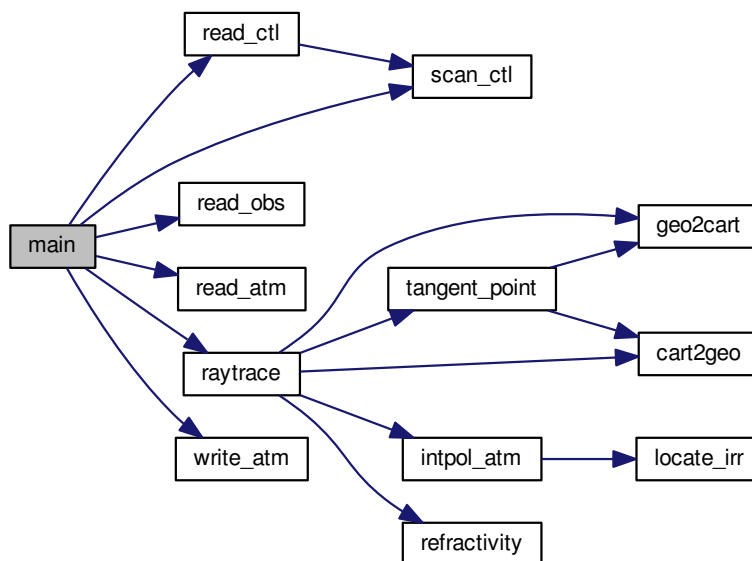
```

```

00105
00106     /* Save data... */
00107     sprintf(filename, "los.%d", ir);
00108     write_atm(NULL, filename, &ctl, &atm2);
00109
00110     /* Get column densities... */
00111     s = 0;
00112     for (ig = 0; ig < ctl.ng; ig++)
00113         u[ig] = 0;
00114     for (ip = 0; ip < los.np; ip++) {
00115         s += los.ds[ip];
00116         for (ig = 0; ig < ctl.ng; ig++)
00117             u[ig] += los.u[ig][ip];
00118     }
00119
00120     /* Write summary data... */
00121     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g",
00122            obs.time[ir], obs.obsz[ir], obs.obslon[ir], obs.obsplat[ir],
00123            obs.vpz[ir], obs.vplon[ir], obs.vplat[ir],
00124            obs.tpz[ir], obs.tplon[ir], obs.tplat[ir], ir, s);
00125     for (ig = 0; ig < ctl.ng; ig++)
00126         fprintf(out, " %g", u[ig]);
00127     fprintf(out, "\n");
00128 }
00129
00130 /* Close file... */
00131 fclose(out);
00132
00133 return EXIT_SUCCESS;
00134 }

```

Here is the call graph for this function:



## 5.26 raytrace.c

```

00001 /*
00002     This file is part of JURASSIC.
00003
00004     JURASSIC is free software: you can redistribute it and/or modify
00005     it under the terms of the GNU General Public License as published by
00006     the Free Software Foundation, either version 3 of the License, or
00007     (at your option) any later version.
00008

```

```

00009  JURASSIC is distributed in the hope that it will be useful,
00010  but WITHOUT ANY WARRANTY; without even the implied warranty of
00011  MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012  GNU General Public License for more details.
00013
00014  You should have received a copy of the GNU General Public License
00015  along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017  Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {
00030
00031     static atm_t atm, atm2;
00032     static ctl_t ctl;
00033     static los_t los;
00034     static obs_t obs;
00035
00036     FILE *out;
00037
00038     char filename[LEN], losbase[LEN];
00039
00040     double u[NG], s;
00041
00042     int ig, ip, ir, iw;
00043
00044     /* Check arguments... */
00045     if (argc < 4)
00046         ERRMSG("Give parameters: <ctl> <obs> <atm>");
00047
00048     /* Read control parameters... */
00049     read_ctl(argc, argv, &ctl);
00050
00051     /* Get basenames... */
00052     scan_ctl(argc, argv, "LOSBASE", -1, "los", losbase);
00053
00054     /* Read observation geometry... */
00055     read_obs(NULL, argv[2], &ctl, &obs);
00056
00057     /* Read atmospheric data... */
00058     read_atm(NULL, argv[3], &ctl, &atm);
00059
00060     /* Write info... */
00061     printf("Write raytrace data: raytrace.tab\n");
00062
00063     /* Create file... */
00064     if (!(out = fopen("raytrace.tab", "w")))
00065         ERRMSG("Cannot create file!");
00066
00067     /* Write header... */
00068     fprintf(out,
00069         "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
00070         "# $2 = observer altitude [km]\n"
00071         "# $3 = observer longitude [deg]\n"
00072         "# $4 = observer latitude [deg]\n"
00073         "# $5 = view point altitude [km]\n"
00074         "# $6 = view point longitude [deg]\n"
00075         "# $7 = view point latitude [deg]\n"
00076         "# $8 = tangent point altitude [km]\n"
00077         "# $9 = tangent point longitude [deg]\n"
00078         "# $10 = tangent point latitude [deg]\n"
00079         "# $11 = ray path index\n" "# $12 = ray path length [km]\n");
00080     for (ig = 0; ig < ctl.ng; ig++)
00081         fprintf(out, "# $d = %s column density [molec/cm^2]\n",
00082             13 + ig, ctl.emitter[ig]);
00083     fprintf(out, "\n");
00084
00085     /* Loop over rays... */
00086     for (ir = 0; ir < obs.nr; ir++) {
00087
00088         /* Raytracing... */
00089         raytrace(&ctl, &atm, &obs, &los, ir);
00090
00091         /* Copy data... */
00092         atm2.np = los.np;
00093         for (ip = 0; ip < los.np; ip++) {
00094             atm2.time[ip] = obs.time[ir];
00095             atm2.z[ip] = los.z[ip];
00096             atm2.lon[ip] = los.lon[ip];
00097             atm2.lat[ip] = los.lat[ip];
00098             atm2.p[ip] = los.p[ip];
00099             atm2.t[ip] = los.t[ip];
00100             for (ig = 0; ig < ctl.ng; ig++)

```

```

00101         atm2.q[ig][ip] = los.q[ig][ip];
00102         for (iw = 0; iw < ctl.nw; iw++)
00103             atm2.k[iw][ip] = los.k[iw][ip];
00104     }
00105
00106     /* Save data... */
00107     sprintf(filename, "los.%d", ir);
00108     write_atm(NULL, filename, &ctl, &atm2);
00109
00110     /* Get column densities... */
00111     s = 0;
00112     for (ig = 0; ig < ctl.ng; ig++)
00113         u[ig] = 0;
00114     for (ip = 0; ip < los.np; ip++) {
00115         s += los.ds[ip];
00116         for (ig = 0; ig < ctl.ng; ig++)
00117             u[ig] += los.u[ig][ip];
00118     }
00119
00120     /* Write summary data... */
00121     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g",
00122            obs.time[ir], obs.obsz[ir], obs.obslon[ir], obs.obsplat[ir],
00123            obs.vpz[ir], obs.vplon[ir], obs.vplat[ir],
00124            obs.tpz[ir], obs.tplon[ir], obs.tplat[ir], ir, s);
00125     for (ig = 0; ig < ctl.ng; ig++)
00126         fprintf(out, " %g", u[ig]);
00127     fprintf(out, "\n");
00128 }
00129
00130 /* Close file... */
00131 fclose(out);
00132
00133 return EXIT_SUCCESS;
00134 }

```

## 5.27 retrieval.c File Reference

JURASSIC retrieval processor.

### Data Structures

- struct [ret\\_t](#)  
*Retrieval control parameters.*

### Functions

- void [analyze\\_avk](#) ([ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [atm\\_t](#) \*atm, int \*iqa, int \*ipa, [gsl\\_matrix](#) \*avk)  
*Compute information content and resolution.*
- void [analyze\\_avk\\_quantity](#) ([gsl\\_matrix](#) \*avk, int iq, int \*ipa, [size\\_t](#) \*n0, [size\\_t](#) \*n1, double \*cont, double \*res)  
*Analyze averaging kernels for individual retrieval target.*
- double [cost\\_function](#) ([gsl\\_vector](#) \*dx, [gsl\\_vector](#) \*dy, [gsl\\_matrix](#) \*s\_a\_inv, [gsl\\_vector](#) \*sig\_eps\_inv)  
*Compute cost function.*
- void [matrix\\_invert](#) ([gsl\\_matrix](#) \*a)  
*Invert symmetric matrix.*
- void [matrix\\_product](#) ([gsl\\_matrix](#) \*a, [gsl\\_vector](#) \*b, int transpose, [gsl\\_matrix](#) \*c)  
*Compute matrix product  $A^T B$  or  $ABA^T$  for diagonal matrix B.*
- void [optimal\\_estimation](#) ([ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [obs\\_t](#) \*obs\_meas, [obs\\_t](#) \*obs\_i, [atm\\_t](#) \*atm\_apr, [atm\\_t](#) \*atm\_i)  
*Carry out optimal estimation retrieval.*
- void [read\\_ret](#) (int argc, char \*argv[], [ctl\\_t](#) \*ctl, [ret\\_t](#) \*ret)  
*Read retrieval control parameters.*
- void [set\\_cov\\_apr](#) ([ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [atm\\_t](#) \*atm, int \*iqa, int \*ipa, [gsl\\_matrix](#) \*s\_a)  
*Set a priori covariance.*

- void [set\\_cov\\_meas](#) ([ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [obs\\_t](#) \*obs, [gsl\\_vector](#) \*sig\_noise, [gsl\\_vector](#) \*sig\_formod, [gsl\\_vector](#) \*sig\_eps\_inv)  
*Set measurement errors.*
- void [write\\_stddev](#) (const char \*quantity, [ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [atm\\_t](#) \*atm, [gsl\\_matrix](#) \*s)  
*Write retrieval error to file.*
- int [main](#) (int argc, char \*argv[])

### 5.27.1 Detailed Description

JURASSIC retrieval processor.

Definition in file [retrieval.c](#).

### 5.27.2 Function Documentation

#### 5.27.2.1 void analyze\_avk ( [ret\\_t](#) \*ret, [ctl\\_t](#) \*ctl, [atm\\_t](#) \*atm, int \*iq, int \*ipa, [gsl\\_matrix](#) \*avk )

Compute information content and resolution.

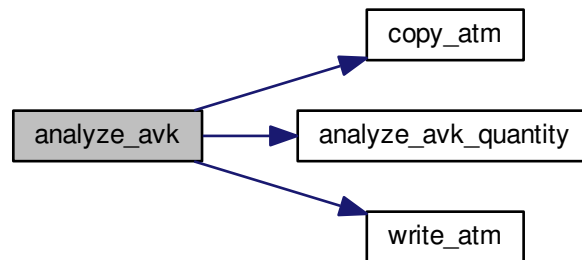
Definition at line 236 of file [retrieval.c](#).

```

00242             {
00243
00244     static atm\_t atm_cont, atm_res;
00245
00246     int ig, iq, iw;
00247
00248     size_t i, n, n0[NQ], n1[NQ];
00249
00250     /* Get sizes... */
00251     n = avk->size1;
00252
00253     /* Find sub-matrices for different quantities... */
00254     for (iq = 0; iq < NQ; iq++) {
00255         n0[iq] = N;
00256         for (i = 0; i < n; i++) {
00257             if (iqa[i] == iq && n0[iq] == N)
00258                 n0[iq] = i;
00259             if (iqa[i] == iq)
00260                 n1[iq] = i - n0[iq] + 1;
00261         }
00262     }
00263
00264     /* Initialize... */
00265     copy_atm(ctl, &atm_cont, atm, 1);
00266     copy_atm(ctl, &atm_res, atm, 1);
00267
00268     /* Analyze quantities... */
00269     analyze_avk_quantity(avk, IDXP, ipa, n0, n1, atm_cont.p, atm_res.
00270 p);
00271     analyze_avk_quantity(avk, IDXT, ipa, n0, n1, atm_cont.t, atm_res.
00272 t);
00273     for (ig = 0; ig < ctl->ng; ig++)
00274         analyze_avk_quantity(avk, IDXQ(ig), ipa, n0, n1,
00275 atm_cont.q[ig], atm_res.q[ig]);
00276     for (iw = 0; iw < ctl->nw; iw++)
00277         analyze_avk_quantity(avk, IDXK(iw), ipa, n0, n1,
00278 atm_cont.k[iw], atm_res.k[iw]);
00279
00280     /* Write results to disk... */
00281     write_atm(ret->dir, "atm_cont.tab", ctl, &atm_cont);
00282     write_atm(ret->dir, "atm_res.tab", ctl, &atm_res);
00283 }

```

Here is the call graph for this function:



**5.27.2.2** void analyze\_avk\_quantity ( gsl\_matrix \* avk, int iq, int \* ipa, size\_t \* n0, size\_t \* n1, double \* cont, double \* res )

Analyze averaging kernels for individual retrieval target.

Definition at line 285 of file [retrieval.c](#).

```

00292         {
00293
00294     size_t i, j;
00295
00296     /* Loop over state vector elements... */
00297     if (n0[iq] < N)
00298         for (i = 0; i < n1[iq]; i++) {
00299
00300             /* Get area of averaging kernel... */
00301             for (j = 0; j < n1[iq]; j++)
00302                 cont[ipa[n0[iq] + i]] += gsl_matrix_get(avk, n0[iq] + i, n0[iq] + j);
00303
00304             /* Get information density... */
00305             res[ipa[n0[iq] + i]] = 1 / gsl_matrix_get(avk, n0[iq] + i, n0[iq] + i);
00306         }
00307     }
  
```

**5.27.2.3** double cost\_function ( gsl\_vector \* dx, gsl\_vector \* dy, gsl\_matrix \* s\_a\_inv, gsl\_vector \* sig\_eps\_inv )

Compute cost function.

Definition at line 311 of file [retrieval.c](#).

```

00315         {
00316
00317     gsl_vector *x_aux, *y_aux;
00318
00319     double chisq_a, chisq_m = 0;
00320
00321     size_t i, m, n;
00322
00323     /* Get sizes... */
00324     m = dy->size;
00325     n = dx->size;
00326
00327     /* Allocate... */
00328     x_aux = gsl_vector_alloc(n);
00329     y_aux = gsl_vector_alloc(m);
00330
00331     /* Determine normalized cost function...
  
```

```

00332     (chi^2 = 1/m * [dy^T * S_eps^{-1} * dy + dx^T * S_a^{-1} * dx]) */
00333     for (i = 0; i < m; i++)
00334         chisq_m += POW2(gsl_vector_get(dy, i) * gsl_vector_get(sig_eps_inv, i));
00335     gsl_blas_dgemv(CblasNoTrans, 1.0, s_a_inv, dx, 0.0, x_aux);
00336     gsl_blas_ddot(dx, x_aux, &chisq_a);
00337
00338     /* Free... */
00339     gsl_vector_free(x_aux);
00340     gsl_vector_free(y_aux);
00341
00342     /* Return cost function value... */
00343     return (chisq_m + chisq_a) / (double) m;
00344 }

```

#### 5.27.2.4 void matrix\_invert ( gsl\_matrix \* a )

Invert symmetric matrix.

Definition at line 348 of file [retrieval.c](#).

```

00349     {
00350
00351         size_t diag = 1, i, j, n;
00352
00353         /* Get size... */
00354         n = a->size1;
00355
00356         /* Check if matrix is diagonal... */
00357         for (i = 0; i < n && diag; i++)
00358             for (j = i + 1; j < n; j++)
00359                 if (gsl_matrix_get(a, i, j) != 0) {
00360                     diag = 0;
00361                     break;
00362                 }
00363
00364         /* Quick inversion of diagonal matrix... */
00365         if (diag)
00366             for (i = 0; i < n; i++)
00367                 gsl_matrix_set(a, i, i, 1 / gsl_matrix_get(a, i, i));
00368
00369         /* Matrix inversion by means of Cholesky decomposition... */
00370         else {
00371             gsl_linalg_cholesky_decomp(a);
00372             gsl_linalg_cholesky_invert(a);
00373         }
00374     }

```

#### 5.27.2.5 void matrix\_product ( gsl\_matrix \* a, gsl\_vector \* b, int transpose, gsl\_matrix \* c )

Compute matrix product  $A^T B A$  or  $A B A^T$  for diagonal matrix B.

Definition at line 378 of file [retrieval.c](#).

```

00382     {
00383
00384         gsl_matrix *aux;
00385
00386         size_t i, j, m, n;
00387
00388         /* Set sizes... */
00389         m = a->size1;
00390         n = a->size2;
00391
00392         /* Allocate... */
00393         aux = gsl_matrix_alloc(m, n);
00394
00395         /* Compute A^T B A... */
00396         if (transpose == 1) {
00397
00398             /* Compute B^1/2 A... */
00399             for (i = 0; i < m; i++)
00400                 for (j = 0; j < n; j++)
00401                     gsl_matrix_set(aux, i, j,
00402                                     gsl_vector_get(b, i) * gsl_matrix_get(a, i, j));

```



```

00403
00404     /* Compute  $A^T B A = (B^{1/2} A)^T (B^{1/2} A) \dots$  */
00405     gsl_blas_dgemm(CblasTrans, CblasNoTrans, 1.0, aux, aux, 0.0, c);
00406 }
00407
00408 /* Compute  $A B A^T \dots$  */
00409 else if (transpose == 2) {
00410
00411     /* Compute  $A B^{1/2} \dots$  */
00412     for (i = 0; i < m; i++)
00413         for (j = 0; j < n; j++)
00414             gsl_matrix_set(aux, i, j,
00415                           gsl_matrix_get(a, i, j) * gsl_vector_get(b, j));
00416
00417     /* Compute  $A B A^T = (A B^{1/2}) (A B^{1/2})^T \dots$  */
00418     gsl_blas_dgemm(CblasNoTrans, CblasTrans, 1.0, aux, aux, 0.0, c);
00419 }
00420
00421 /* Free... */
00422 gsl_matrix_free(aux);
00423 }

```

**5.27.2.6 void optimal\_estimation ( ret\_t \* ret, ctl\_t \* ctl, obs\_t \* obs\_meas, obs\_t \* obs\_i, atm\_t \* atm\_apr, atm\_t \* atm\_i )**

Carry out optimal estimation retrieval.

Definition at line 427 of file [retrieval.c](#).

```

00433     {
00434
00435     static int ipa[N], iqa[N];
00436
00437     gsl_matrix *a, *auxnm, *corr, *cov, *gain, *k_i, *s_a_inv;
00438     gsl_vector *b, *dx, *dy, *sig_eps_inv, *sig_formod, *sig_noise,
00439         *x_a, *x_i, *x_step, *y_aux, *y_i, *y_m;
00440
00441     FILE *out;
00442
00443     char filename[LEN];
00444
00445     double chisq, chisq_old, disq = 0, lmpar = 0.001;
00446
00447     int ig, ip, it = 0, it2, iw;
00448
00449     size_t i, j, m, n;
00450
00451     /* -----
00452        Initialize...
00453        ----- */
00454
00455     /* Get sizes... */
00456     m = obs2y(ctl, obs_meas, NULL, NULL, NULL);
00457     n = atm2x(ctl, atm_apr, NULL, iqa, ipa);
00458     if (m <= 0 || n <= 0)
00459         ERRMSG("Check problem definition!");
00460
00461     /* Write info... */
00462     printf("Problem size: m= %d / n= %d "
00463           "(alloc= %.4g MB / stat= %.4g MB)\n",
00464           (int) m, (int) n,
00465           (double) (3 * m * n + 4 * n * n + 8 * m +
00466                   8 * n) * sizeof(double) / 1024. / 1024.,
00467           (double) (5 * sizeof(atm_t) + 3 * sizeof(obs_t)
00468                   + 2 * N * sizeof(int)) / 1024. / 1024.);
00469
00470     /* Allocate... */
00471     a = gsl_matrix_alloc(n, n);
00472     cov = gsl_matrix_alloc(n, n);
00473     k_i = gsl_matrix_alloc(m, n);
00474     s_a_inv = gsl_matrix_alloc(n, n);
00475
00476     b = gsl_vector_alloc(n);
00477     dx = gsl_vector_alloc(n);
00478     dy = gsl_vector_alloc(m);
00479     sig_eps_inv = gsl_vector_alloc(m);
00480     sig_formod = gsl_vector_alloc(m);
00481     sig_noise = gsl_vector_alloc(m);
00482     x_a = gsl_vector_alloc(n);
00483     x_i = gsl_vector_alloc(n);

```

```

00484 x_step = gsl_vector_alloc(n);
00485 y_aux = gsl_vector_alloc(m);
00486 y_i = gsl_vector_alloc(m);
00487 y_m = gsl_vector_alloc(m);
00488
00489 /* Set initial state... */
00490 copy_atm(ctl, atm_i, atm_apr, 0);
00491 copy_obs(ctl, obs_i, obs_meas, 0);
00492 formod(ctl, atm_i, obs_i);
00493
00494 /* Set state vectors and observation vectors... */
00495 atm2x(ctl, atm_apr, x_a, NULL, NULL);
00496 atm2x(ctl, atm_i, x_i, NULL, NULL);
00497 obs2y(ctl, obs_meas, y_m, NULL, NULL);
00498 obs2y(ctl, obs_i, y_i, NULL, NULL);
00499
00500 /* Set inverse a priori covariance S_a^-1... */
00501 set_cov_apr(ret, ctl, atm_apr, iqa, ipa, s_a_inv);
00502 write_matrix(ret->dir, "matrix_cov_apr.tab", ctl, s_a_inv,
00503             atm_i, obs_i, "x", "x", "r");
00504 matrix_invert(s_a_inv);
00505
00506 /* Get measurement errors... */
00507 set_cov_meas(ret, ctl, obs_meas, sig_noise, sig_formod, sig_eps_inv);
00508
00509 /* Create cost function file... */
00510 sprintf(filename, "%s/costs.tab", ret->dir);
00511 if (!out = fopen(filename, "w"))
00512     ERRMSG("Cannot create cost function file!");
00513
00514 /* Write header... */
00515 fprintf(out,
00516         "# $1 = iteration number\n"
00517         "# $2 = normalized cost function\n"
00518         "# $3 = number of measurements\n"
00519         "# $4 = number of state vector elements\n\n");
00520
00521 /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00522 gsl_vector_memcpy(dx, x_i);
00523 gsl_vector_sub(dx, x_a);
00524 gsl_vector_memcpy(dy, y_m);
00525 gsl_vector_sub(dy, y_i);
00526
00527 /* Compute cost function... */
00528 chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00529
00530 /* Write info... */
00531 printf("it= %d / chi^2/m= %g\n", it, chisq);
00532
00533 /* Write to cost function file... */
00534 fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00535
00536 /* Compute initial kernel... */
00537 kernel(ctl, atm_i, obs_i, k_i);
00538
00539 /* -----
00540      Levenberg-Marquardt minimization...
00541      ----- */
00542
00543 /* Outer loop... */
00544 for (it = 1; it <= ret->conv_itmax; it++) {
00545
00546     /* Store current cost function value... */
00547     chisq_old = chisq;
00548
00549     /* Compute kernel matrix K_i... */
00550     if (it > 1 && it % ret->kernel_recomp == 0)
00551         kernel(ctl, atm_i, obs_i, k_i);
00552
00553     /* Compute K_i^T * S_eps^{-1} * K_i ... */
00554     if (it == 1 || it % ret->kernel_recomp == 0)
00555         matrix_product(k_i, sig_eps_inv, 1, cov);
00556
00557     /* Determine b = K_i^T * S_eps^{-1} * dy - S_a^{-1} * dx ... */
00558     for (i = 0; i < m; i++)
00559         gsl_vector_set(y_aux, i, gsl_vector_get(dy, i)
00560                       * POW2(gsl_vector_get(sig_eps_inv, i)));
00561     gsl_blas_dgemv(CblasTrans, 1.0, k_i, y_aux, 0.0, b);
00562     gsl_blas_dgemv(CblasNoTrans, -1.0, s_a_inv, dx, 1.0, b);
00563
00564     /* Inner loop... */
00565     for (it2 = 0; it2 < 20; it2++) {
00566
00567         /* Compute A = (1 + lmpar) * S_a^{-1} + K_i^T * S_eps^{-1} * K_i ... */
00568         gsl_matrix_memcpy(a, s_a_inv);
00569         gsl_matrix_scale(a, 1 + lmpar);
00570         gsl_matrix_add(a, cov);

```

```

00571
00572 /* Solve A * x_step = b by means of Cholesky decomposition... */
00573 gsl_linalg_cholesky_decomp(a);
00574 gsl_linalg_cholesky_solve(a, b, x_step);
00575
00576 /* Update atmospheric state... */
00577 gsl_vector_add(x_i, x_step);
00578 copy_atm(ctl, atm_i, atm_apr, 0);
00579 copy_obs(ctl, obs_i, obs_meas, 0);
00580 x2atm(ctl, x_i, atm_i);
00581
00582 /* Check atmospheric state... */
00583 for (ip = 0; ip < atm_i->np; ip++) {
00584     atm_i->p[ip] = GSL_MIN(GSL_MAX(atm_i->p[ip], 5e-7), 5e4);
00585     atm_i->t[ip] = GSL_MIN(GSL_MAX(atm_i->t[ip], 100), 400);
00586     for (ig = 0; ig < ctl->ng; ig++)
00587         atm_i->q[ig][ip] = GSL_MIN(GSL_MAX(atm_i->q[ig][ip], 0), 1);
00588     for (iw = 0; iw < ctl->nw; iw++)
00589         atm_i->k[iw][ip] = GSL_MAX(atm_i->k[iw][ip], 0);
00590 }
00591
00592 /* Forward calculation... */
00593 formod(ctl, atm_i, obs_i);
00594 obs2y(ctl, obs_i, y_i, NULL, NULL);
00595
00596 /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00597 gsl_vector_memcpy(dx, x_i);
00598 gsl_vector_sub(dx, x_a);
00599 gsl_vector_memcpy(dy, y_m);
00600 gsl_vector_sub(dy, y_i);
00601
00602 /* Compute cost function... */
00603 chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00604
00605 /* Modify Levenberg-Marquardt parameter... */
00606 if (chisq > chisq_old) {
00607     lmpar *= 10;
00608     gsl_vector_sub(x_i, x_step);
00609 } else {
00610     lmpar /= 10;
00611     break;
00612 }
00613 }
00614
00615 /* Write info... */
00616 printf("it= %d / chi^2/m= %g\n", it, chisq);
00617
00618 /* Write to cost function file... */
00619 fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00620
00621 /* Get normalized step size in state space... */
00622 gsl_blas_ddot(x_step, b, &disq);
00623 disq /= (double) n;
00624
00625 /* Convergence test... */
00626 if ((it == 1 || it % ret->kernel_recomp == 0) && disq < ret->
conv_dmin)
    break;
00627 }
00628 }
00629
00630 /* Close cost function file... */
00631 fclose(out);
00632
00633 /* Store results... */
00634 write_atm(ret->dir, "atm_final.tab", ctl, atm_i);
00635 write_obs(ret->dir, "obs_final.tab", ctl, obs_i);
00636 write_matrix(ret->dir, "matrix_kernel.tab", ctl, k_i,
00637             atm_i, obs_i, "y", "x", "r");
00638
00639 /* -----
00640 Analysis of retrieval results...
00641 ----- */
00642
00643 /* Check if error analysis is requested... */
00644 if (ret->err_ana) {
00645
00646     /* Allocate... */
00647     auxnm = gsl_matrix_alloc(n, m);
00648     corr = gsl_matrix_alloc(n, n);
00649     gain = gsl_matrix_alloc(n, m);
00650
00651     /* Compute inverse retrieval covariance...
00652      cov^{-1} = S_a^{-1} + K_i^T * S_eps^{-1} * K_i */
00653     matrix_product(k_i, sig_eps_inv, 1, cov);
00654     gsl_matrix_add(cov, s_a_inv);
00655
00656     /* Compute retrieval covariance... */

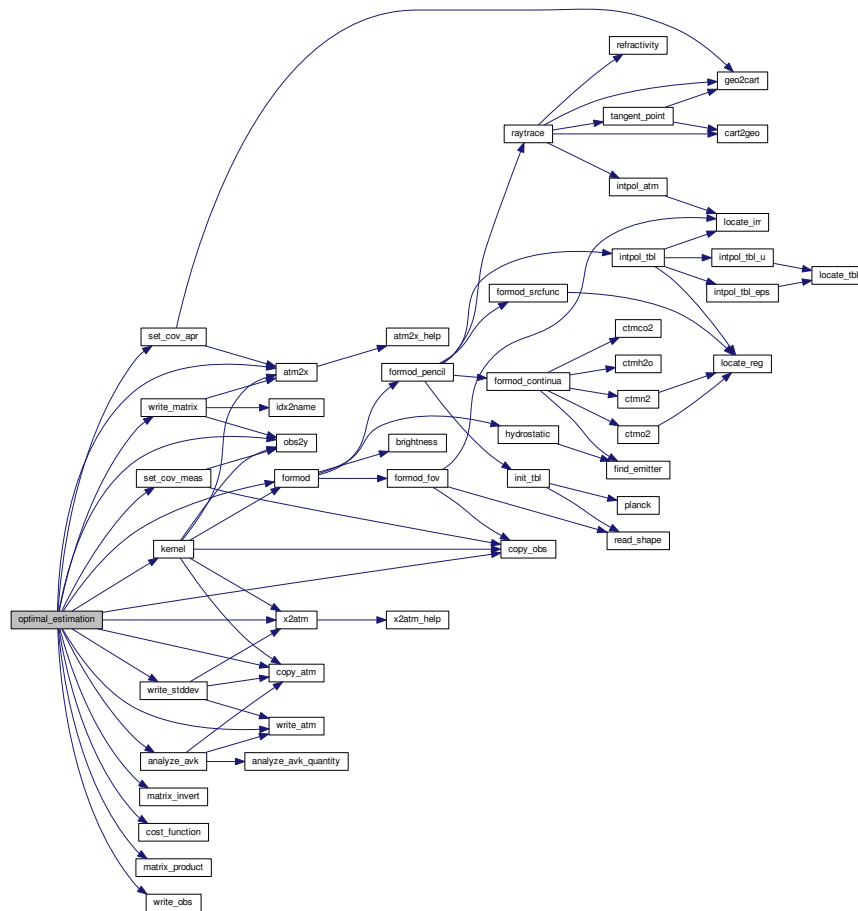
```

```

00657     matrix_invert(cov);
00658     write_matrix(ret->dir, "matrix_cov_ret.tab", ctl, cov,
00659                 atm_i, obs_i, "x", "x", "r");
00660     write_stddev("total", ret, ctl, atm_i, cov);
00661
00662     /* Compute correlation matrix... */
00663     for (i = 0; i < n; i++)
00664         for (j = 0; j < n; j++)
00665             gsl_matrix_set(corr, i, j, gsl_matrix_get(cov, i, j)
00666                           / sqrt(gsl_matrix_get(cov, i, i))
00667                           / sqrt(gsl_matrix_get(cov, j, j)));
00668     write_matrix(ret->dir, "matrix_corr.tab", ctl, corr,
00669                 atm_i, obs_i, "x", "x", "r");
00670
00671     /* Compute gain matrix...
00672     G = cov * K^T * S_eps^{-1} */
00673     for (i = 0; i < n; i++)
00674         for (j = 0; j < m; j++)
00675             gsl_matrix_set(auxnm, i, j, gsl_matrix_get(k_i, j, i)
00676                           * POW2(gsl_vector_get(sig_eps_inv, j)));
00677     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, cov, auxnm, 0.0, gain);
00678     write_matrix(ret->dir, "matrix_gain.tab", ctl, gain,
00679                 atm_i, obs_i, "x", "y", "c");
00680
00681     /* Compute retrieval error due to noise... */
00682     matrix_product(gain, sig_noise, 2, a);
00683     write_stddev("noise", ret, ctl, atm_i, a);
00684
00685     /* Compute retrieval error due to forward model errors... */
00686     matrix_product(gain, sig_formod, 2, a);
00687     write_stddev("formod", ret, ctl, atm_i, a);
00688
00689     /* Compute averaging kernel matrix
00690     A = G * K ... */
00691     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, gain, k_i, 0.0, a);
00692     write_matrix(ret->dir, "matrix_avk.tab", ctl, a,
00693                 atm_i, obs_i, "x", "x", "r");
00694
00695     /* Analyze averaging kernel matrix... */
00696     analyze_avk(ret, ctl, atm_i, iqa, ipa, a);
00697
00698     /* Free... */
00699     gsl_matrix_free(auxnm);
00700     gsl_matrix_free(corr);
00701     gsl_matrix_free(gain);
00702 }
00703
00704 /* -----
00705     Finalize...
00706     ----- */
00707
00708     gsl_matrix_free(a);
00709     gsl_matrix_free(cov);
00710     gsl_matrix_free(k_i);
00711     gsl_matrix_free(s_a_inv);
00712
00713     gsl_vector_free(b);
00714     gsl_vector_free(dx);
00715     gsl_vector_free(dy);
00716     gsl_vector_free(sig_eps_inv);
00717     gsl_vector_free(sig_formod);
00718     gsl_vector_free(sig_noise);
00719     gsl_vector_free(x_a);
00720     gsl_vector_free(x_i);
00721     gsl_vector_free(x_step);
00722     gsl_vector_free(y_aux);
00723     gsl_vector_free(y_i);
00724     gsl_vector_free(y_m);
00725 }

```

Here is the call graph for this function:



### 5.27.2.7 void read\_ret ( int argc, char \* argv[], ctl\_t \* ctl, ret\_t \* ret )

Read retrieval control parameters.

Definition at line 729 of file [retrieval.c](#).

```

00733         {
00734
00735     int id, ig, iw;
00736
00737     /* Iteration control... */
00738     ret->kernel_recomp =
00739         (int) scan_ctl(argc, argv, "KERNEL_RECOMP", -1, "3", NULL);
00740     ret->conv_itmax = (int) scan_ctl(argc, argv, "CONV_ITMAX", -1, "30", NULL);
00741     ret->conv_dmin = scan_ctl(argc, argv, "CONV_DMIN", -1, "0.1", NULL);
00742
00743     /* Error analysis... */
00744     ret->err_ana = (int) scan_ctl(argc, argv, "ERR_ANA", -1, "1", NULL);
00745
00746     for (id = 0; id < ctl->nd; id++)
00747         ret->err_formod[id] = scan_ctl(argc, argv, "ERR_FORMOD", id, "0", NULL);
00748
00749     for (id = 0; id < ctl->nd; id++)
00750         ret->err_noise[id] = scan_ctl(argc, argv, "ERR_NOISE", id, "0", NULL);
00751
00752     ret->err_press = scan_ctl(argc, argv, "ERR_PRESS", -1, "0", NULL);
00753     ret->err_press_cz = scan_ctl(argc, argv, "ERR_PRESS_CZ", -1, "-999", NULL);
00754     ret->err_press_ch = scan_ctl(argc, argv, "ERR_PRESS_CH", -1, "-999", NULL);
00755

```

```

00756 ret->err_temp = scan_ctl(argc, argv, "ERR_TEMP", -1, "0", NULL);
00757 ret->err_temp_cz = scan_ctl(argc, argv, "ERR_TEMP_CZ", -1, "-999", NULL);
00758 ret->err_temp_ch = scan_ctl(argc, argv, "ERR_TEMP_CH", -1, "-999", NULL);
00759
00760 for (ig = 0; ig < ctl->ng; ig++) {
00761     ret->err_q[ig] = scan_ctl(argc, argv, "ERR_Q", ig, "0", NULL);
00762     ret->err_q_cz[ig] = scan_ctl(argc, argv, "ERR_Q_CZ", ig, "-999", NULL);
00763     ret->err_q_ch[ig] = scan_ctl(argc, argv, "ERR_Q_CH", ig, "-999", NULL);
00764 }
00765
00766 for (iw = 0; iw < ctl->nw; iw++) {
00767     ret->err_k[iw] = scan_ctl(argc, argv, "ERR_K", iw, "0", NULL);
00768     ret->err_k_cz[iw] = scan_ctl(argc, argv, "ERR_K_CZ", iw, "-999", NULL);
00769     ret->err_k_ch[iw] = scan_ctl(argc, argv, "ERR_K_CH", iw, "-999", NULL);
00770 }
00771 }

```

Here is the call graph for this function:



#### 5.27.2.8 void set\_cov\_apr ( ret\_t \* ret, ctl\_t \* ctl, atm\_t \* atm, int \* iqa, int \* ipa, gsl\_matrix \* s\_a )

Set a priori covariance.

Definition at line 775 of file [retrieval.c](#).

```

00781 {
00782
00783     gsl_vector *x_a;
00784
00785     double ch, cz, rho, x0[3], x1[3];
00786
00787     int ig, iw;
00788
00789     size_t i, j, n;
00790
00791     /* Get sizes... */
00792     n = s_a->size1;
00793
00794     /* Allocate... */
00795     x_a = gsl_vector_alloc(n);
00796
00797     /* Get sigma vector... */
00798     atm2x(ctl, atm, x_a, NULL, NULL);
00799     for (i = 0; i < n; i++) {
00800         if (iqa[i] == IDXP)
00801             gsl_vector_set(x_a, i, ret->err_press / 100 * gsl_vector_get(x_a, i));
00802         if (iqa[i] == IDXT)
00803             gsl_vector_set(x_a, i, ret->err_temp);
00804         for (ig = 0; ig < ctl->ng; ig++)
00805             if (iqa[i] == IDXQ(ig))
00806                 gsl_vector_set(x_a, i, ret->err_q[ig] / 100 * gsl_vector_get(x_a, i));
00807         for (iw = 0; iw < ctl->nw; iw++)
00808             if (iqa[i] == IDXK(iw))
00809                 gsl_vector_set(x_a, i, ret->err_k[iw]);
00810     }
00811
00812     /* Check standard deviations... */
00813     for (i = 0; i < n; i++)
00814         if (POW2(gsl_vector_get(x_a, i)) <= 0)
00815             ERRMSG("Check a priori data (zero standard deviation)!");
00816
00817     /* Initialize diagonal covariance... */

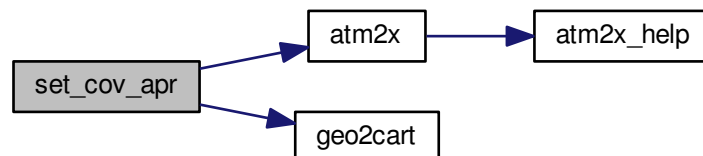
```

```

00818   gsl_matrix_set_zero(s_a);
00819   for (i = 0; i < n; i++)
00820     gsl_matrix_set(s_a, i, i, POW2(gsl_vector_get(x_a, i)));
00821
00822   /* Loop over matrix elements... */
00823   for (i = 0; i < n; i++)
00824     for (j = 0; j < n; j++)
00825       if (i != j && iqa[i] == iqa[j]) {
00826
00827         /* Initialize... */
00828         cz = ch = 0;
00829
00830         /* Set correlation lengths for pressure... */
00831         if (iqa[i] == IDXP) {
00832           cz = ret->err_press_cz;
00833           ch = ret->err_press_ch;
00834         }
00835
00836         /* Set correlation lengths for temperature... */
00837         if (iqa[i] == IDXT) {
00838           cz = ret->err_temp_cz;
00839           ch = ret->err_temp_ch;
00840         }
00841
00842         /* Set correlation lengths for volume mixing ratios... */
00843         for (ig = 0; ig < ctl->ng; ig++)
00844           if (iqa[i] == IDXQ(ig)) {
00845             cz = ret->err_q_cz[ig];
00846             ch = ret->err_q_ch[ig];
00847           }
00848
00849         /* Set correlation lengths for extinction... */
00850         for (iw = 0; iw < ctl->nw; iw++)
00851           if (iqa[i] == IDXK(iw)) {
00852             cz = ret->err_k_cz[iw];
00853             ch = ret->err_k_ch[iw];
00854           }
00855
00856         /* Compute correlations... */
00857         if (cz > 0 && ch > 0) {
00858
00859           /* Get Cartesian coordinates... */
00860           geo2cart(0, atm->lon[ipa[i]], atm->lat[ipa[i]], x0);
00861           geo2cart(0, atm->lon[ipa[j]], atm->lat[ipa[j]], x1);
00862
00863           /* Compute correlations... */
00864           rho =
00865             exp(-DIST(x0, x1) / ch -
00866               fabs(atm->z[ipa[i]] - atm->z[ipa[j]]) / cz);
00867
00868           /* Set covariance... */
00869           gsl_matrix_set(s_a, i, j, gsl_vector_get(x_a, i)
00870             * gsl_vector_get(x_a, j) * rho);
00871         }
00872       }
00873
00874   /* Free... */
00875   gsl_vector_free(x_a);
00876 }

```

Here is the call graph for this function:



**5.27.2.9** void `set_cov_meas` ( `ret_t` \* *ret*, `ctl_t` \* *ctl*, `obs_t` \* *obs*, `gsl_vector` \* *sig\_noise*, `gsl_vector` \* *sig\_formod*, `gsl_vector` \* *sig\_eps\_inv* )

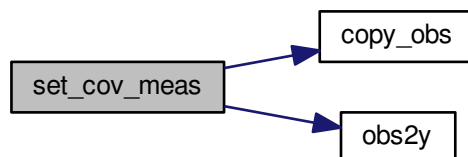
Set measurement errors.

Definition at line 880 of file [retrieval.c](#).

```

00886                                     {
00887
00888     static obs_t obs_err;
00889
00890     int id, ir;
00891
00892     size_t i, m;
00893
00894     /* Get size... */
00895     m = sig_eps_inv->size;
00896
00897     /* Noise error (always considered in retrieval fit)... */
00898     copy_obs(ctl, &obs_err, obs, 1);
00899     for (ir = 0; ir < obs_err.nr; ir++)
00900         for (id = 0; id < ctl->nd; id++)
00901             obs_err.rad[id][ir]
00902                 = (gsl_finite(obs->rad[id][ir]) ? ret->err_noise[id] : GSL_NAN);
00903     obs2y(ctl, &obs_err, sig_noise, NULL, NULL);
00904
00905     /* Forward model error (always considered in retrieval fit)... */
00906     copy_obs(ctl, &obs_err, obs, 1);
00907     for (ir = 0; ir < obs_err.nr; ir++)
00908         for (id = 0; id < ctl->nd; id++)
00909             obs_err.rad[id][ir]
00910                 = fabs(ret->err_formod[id] / 100 * obs->rad[id][ir]);
00911     obs2y(ctl, &obs_err, sig_formod, NULL, NULL);
00912
00913     /* Total error... */
00914     for (i = 0; i < m; i++)
00915         gsl_vector_set(sig_eps_inv, i, 1 / sqrt(POW2(gsl_vector_get(sig_noise, i))
00916                                                     +
00917                                                     POW2(gsl_vector_get
00918                                                         (sig_formod, i))));
00919
00920     /* Check standard deviations... */
00921     for (i = 0; i < m; i++)
00922         if (gsl_vector_get(sig_eps_inv, i) <= 0)
00923             ERRMSG("Check measurement errors (zero standard deviation)!");
00924 }
```

Here is the call graph for this function:



**5.27.2.10** void `write_stddev` ( `const char` \* *quantity*, `ret_t` \* *ret*, `ctl_t` \* *ctl*, `atm_t` \* *atm*, `gsl_matrix` \* *s* )

Write retrieval error to file.

Definition at line 928 of file [retrieval.c](#).

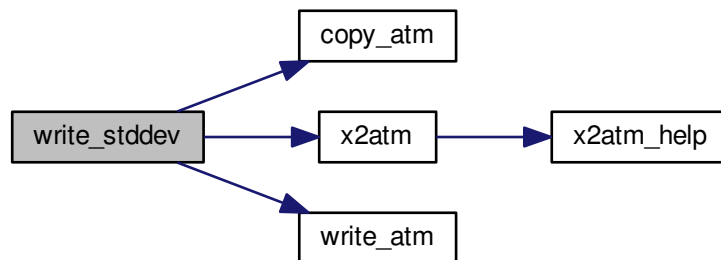


```

00933         {
00934
00935     static atm_t atm_aux;
00936
00937     gsl_vector *x_aux;
00938
00939     char filename[LEN];
00940
00941     size_t i, n;
00942
00943     /* Get sizes... */
00944     n = s->size1;
00945
00946     /* Allocate... */
00947     x_aux = gsl_vector_alloc(n);
00948
00949     /* Compute standard deviation... */
00950     for (i = 0; i < n; i++)
00951         gsl_vector_set(x_aux, i, sqrt(gsl_matrix_get(s, i, i)));
00952
00953     /* Write to disk... */
00954     copy_atm(ctl, &atm_aux, atm, 1);
00955     x2atm(ctl, x_aux, &atm_aux);
00956     sprintf(filename, "atm_err_%s.tab", quantity);
00957     write_atm(ret->dir, filename, ctl, &atm_aux);
00958
00959     /* Free... */
00960     gsl_vector_free(x_aux);
00961 }

```

Here is the call graph for this function:



#### 5.27.2.11 int main ( int argc, char \* argv[] )

Definition at line 180 of file [retrieval.c](#).

```

00182         {
00183
00184     static atm_t atm_i, atm_apr;
00185     static ctl_t ctl;
00186     static obs_t obs_i, obs_meas;
00187     static ret_t ret;
00188
00189     FILE *dirlist;
00190
00191     /* Check arguments... */
00192     if (argc < 3)
00193         ERRMSG("Give parameters: <ctl> <dirlist>");
00194
00195     /* Measure CPU-time... */
00196     TIMER("total", 1);
00197
00198     /* Read control parameters... */
00199     read_ctl(argc, argv, &ctl);

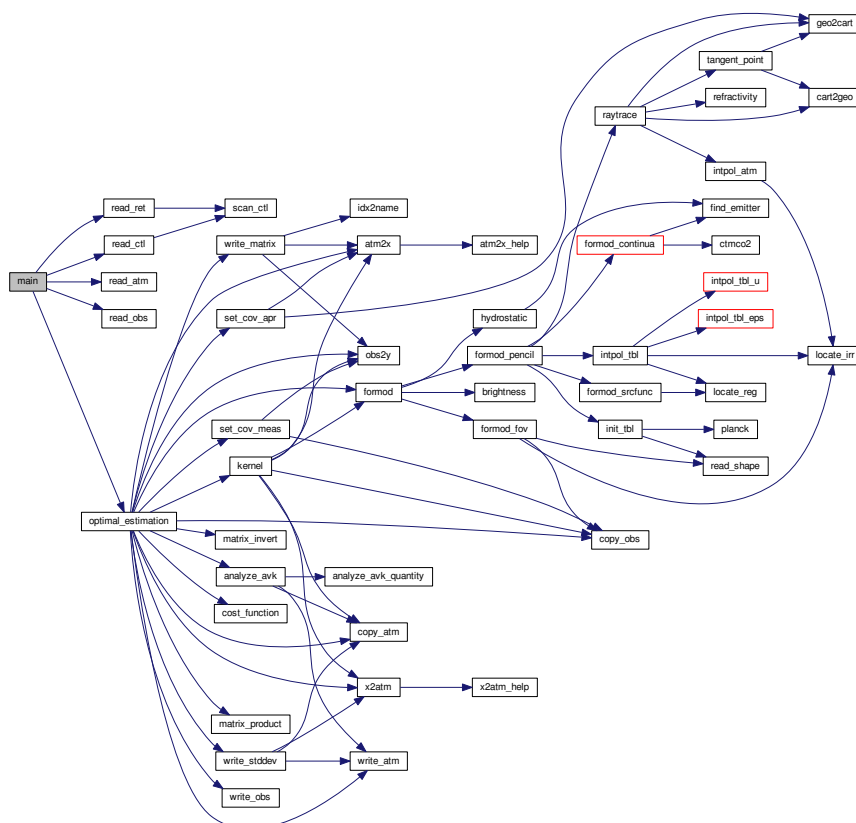
```

```

00200 read_ret(argv, &ctl, &ret);
00201
00202 /* Open directory list... */
00203 if (!(dirlist = fopen(argv[2], "r")))
00204     ERRMSG("Cannot open directory list!");
00205
00206 /* Loop over directories... */
00207 while (fscanf(dirlist, "%s", ret.dir) != EOF) {
00208
00209     /* Write info... */
00210     printf("\nRetrieve in directory %s...\n\n", ret.dir);
00211
00212     /* Read atmospheric data... */
00213     read_atm(ret.dir, "atm_apr.tab", &ctl, &atm_apr);
00214
00215     /* Read observation data... */
00216     read_obs(ret.dir, "obs_meas.tab", &ctl, &obs_meas);
00217
00218     /* Run retrieval... */
00219     optimal_estimation(&ret, &ctl, &obs_meas, &obs_i, &atm_apr, &atm_i);
00220
00221     /* Measure CPU-time... */
00222     TIMER("total", 2);
00223 }
00224
00225 /* Write info... */
00226 printf("\nRetrieval done...\n");
00227
00228 /* Measure CPU-time... */
00229 TIMER("total", 3);
00230
00231 return EXIT_SUCCESS;
00232 }

```

Here is the call graph for this function:



## 5.28 retrieval.c

00001 /\*

```

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00017 Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /* -----
00028     Structs...
00029     ----- */
00030
00032 typedef struct {
00033
00035     char dir[LEN];
00036
00038     int kernel_recomp;
00039
00041     int conv_itmax;
00042
00044     double conv_dmin;
00045
00047     int err_ana;
00048
00050     double err_formod[ND];
00051
00053     double err_noise[ND];
00054
00056     double err_press;
00057
00059     double err_press_cz;
00060
00062     double err_press_ch;
00063
00065     double err_temp;
00066
00068     double err_temp_cz;
00069
00071     double err_temp_ch;
00072
00074     double err_q[NG];
00075
00077     double err_q_cz[NG];
00078
00080     double err_q_ch[NG];
00081
00083     double err_k[NW];
00084
00086     double err_k_cz[NW];
00087
00089     double err_k_ch[NW];
00090
00091 } ret_t;
00092
00093 /* -----
00094     Functions...
00095     ----- */
00096
00098 void analyze_avk(
00099     ret_t * ret,
00100     ctl_t * ctl,
00101     atm_t * atm,
00102     int *iqa,
00103     int *ipa,
00104     gsl_matrix * avk);
00105
00107 void analyze_avk_quantity(
00108     gsl_matrix * avk,
00109     int iq,
00110     int ipa,
00111     size_t * n0,
00112     size_t * n1,
00113     double *cont,
00114     double *res);
00115

```

```

00117 double cost_function(
00118     gsl_vector * dx,
00119     gsl_vector * dy,
00120     gsl_matrix * s_a_inv,
00121     gsl_vector * sig_eps_inv);
00122
00124 void matrix_invert(
00125     gsl_matrix * a);
00126
00128 void matrix_product(
00129     gsl_matrix * a,
00130     gsl_vector * b,
00131     int transpose,
00132     gsl_matrix * c);
00133
00135 void optimal_estimation(
00136     ret_t * ret,
00137     ctl_t * ctl,
00138     obs_t * obs_meas,
00139     obs_t * obs_i,
00140     atm_t * atm_apr,
00141     atm_t * atm_i);
00142
00144 void read_ret(
00145     int argc,
00146     char *argv[],
00147     ctl_t * ctl,
00148     ret_t * ret);
00149
00151 void set_cov_apr(
00152     ret_t * ret,
00153     ctl_t * ctl,
00154     atm_t * atm,
00155     int *iqa,
00156     int *ipa,
00157     gsl_matrix * s_a);
00158
00160 void set_cov_meas(
00161     ret_t * ret,
00162     ctl_t * ctl,
00163     obs_t * obs,
00164     gsl_vector * sig_noise,
00165     gsl_vector * sig_formod,
00166     gsl_vector * sig_eps_inv);
00167
00169 void write_stddev(
00170     const char *quantity,
00171     ret_t * ret,
00172     ctl_t * ctl,
00173     atm_t * atm,
00174     gsl_matrix * s);
00175
00176 /* -----
00177     Main...
00178     ----- */
00179
00180 int main(
00181     int argc,
00182     char *argv[]) {
00183
00184     static atm_t atm_i, atm_apr;
00185     static ctl_t ctl;
00186     static obs_t obs_i, obs_meas;
00187     static ret_t ret;
00188
00189     FILE *dirlist;
00190
00191     /* Check arguments... */
00192     if (argc < 3)
00193         ERRMSG("Give parameters: <ctl> <dirlist>");
00194
00195     /* Measure CPU-time... */
00196     TIMER("total", 1);
00197
00198     /* Read control parameters... */
00199     read_ctl(argc, argv, &ctl);
00200     read_ret(argc, argv, &ctl, &ret);
00201
00202     /* Open directory list... */
00203     if (!(dirlist = fopen(argv[2], "r")))
00204         ERRMSG("Cannot open directory list!");
00205
00206     /* Loop over directories... */
00207     while (fscanf(dirlist, "%s", ret.dir) != EOF) {
00208
00209         /* Write info... */
00210         printf("\nRetrieve in directory %s...\n\n", ret.dir);

```

```

00211
00212     /* Read atmospheric data... */
00213     read_atm(ret.dir, "atm_apr.tab", &ctl, &atm_apr);
00214
00215     /* Read observation data... */
00216     read_obs(ret.dir, "obs_meas.tab", &ctl, &obs_meas);
00217
00218     /* Run retrieval... */
00219     optimal_estimation(&ret, &ctl, &obs_meas, &obs_i, &atm_apr, &atm_i);
00220
00221     /* Measure CPU-time... */
00222     TIMER("total", 2);
00223 }
00224
00225 /* Write info... */
00226 printf("\nRetrieval done...\n");
00227
00228 /* Measure CPU-time... */
00229 TIMER("total", 3);
00230
00231 return EXIT_SUCCESS;
00232 }
00233
00234 /*****
00235 void analyze_avk(
00236     ret_t * ret,
00237     ctl_t * ctl,
00238     atm_t * atm,
00239     int *ipa,
00240     int *ipa,
00241     gsl_matrix * avk) {
00242     static atm_t atm_cont, atm_res;
00243
00244     int ig, iq, iw;
00245
00246     size_t i, n, n0[NQ], n1[NQ];
00247
00248     /* Get sizes... */
00249     n = avk->size1;
00250
00251     /* Find sub-matrices for different quantities... */
00252     for (iq = 0; iq < NQ; iq++) {
00253         n0[iq] = N;
00254         for (i = 0; i < n; i++) {
00255             if (ipa[i] == iq && n0[iq] == N)
00256                 n0[iq] = i;
00257             if (ipa[i] == iq)
00258                 n1[iq] = i - n0[iq] + 1;
00259         }
00260     }
00261
00262     /* Initialize... */
00263     copy_atm(ctl, &atm_cont, atm, 1);
00264     copy_atm(ctl, &atm_res, atm, 1);
00265
00266     /* Analyze quantities... */
00267     analyze_avk_quantity(avk, IDXP, ipa, n0, n1, atm_cont.p, atm_res.
00268 p);
00269     analyze_avk_quantity(avk, IDXT, ipa, n0, n1, atm_cont.t, atm_res.
00270 t);
00271     for (ig = 0; ig < ctl->ng; ig++)
00272         analyze_avk_quantity(avk, IDXQ(ig), ipa, n0, n1,
00273             atm_cont.q[ig], atm_res.q[ig]);
00274     for (iw = 0; iw < ctl->nw; iw++)
00275         analyze_avk_quantity(avk, IDXK(iw), ipa, n0, n1,
00276             atm_cont.k[iw], atm_res.k[iw]);
00277
00278     /* Write results to disk... */
00279     write_atm(ret->dir, "atm_cont.tab", ctl, &atm_cont);
00280     write_atm(ret->dir, "atm_res.tab", ctl, &atm_res);
00281 }
00282
00283 /*****
00284 void analyze_avk_quantity(
00285     gsl_matrix * avk,
00286     int iq,
00287     int *ipa,
00288     size_t * n0,
00289     size_t * n1,
00290     double *cont,
00291     double *res) {
00292     size_t i, j;
00293
00294
00295

```

```

00296  /* Loop over state vector elements... */
00297  if (n0[iq] < N)
00298      for (i = 0; i < n1[iq]; i++) {
00299
00300      /* Get area of averaging kernel... */
00301      for (j = 0; j < n1[iq]; j++)
00302          cont[ipa[n0[iq] + i]] += gsl_matrix_get(avk, n0[iq] + i, n0[iq] + j);
00303
00304      /* Get information density... */
00305      res[ipa[n0[iq] + i]] = 1 / gsl_matrix_get(avk, n0[iq] + i, n0[iq] + i);
00306      }
00307  }
00308
00309  /*****
00310
00311  double cost_function(
00312      gsl_vector * dx,
00313      gsl_vector * dy,
00314      gsl_matrix * s_a_inv,
00315      gsl_vector * sig_eps_inv) {
00316
00317      gsl_vector *x_aux, *y_aux;
00318
00319      double chisq_a, chisq_m = 0;
00320
00321      size_t i, m, n;
00322
00323      /* Get sizes... */
00324      m = dy->size;
00325      n = dx->size;
00326
00327      /* Allocate... */
00328      x_aux = gsl_vector_alloc(n);
00329      y_aux = gsl_vector_alloc(m);
00330
00331      /* Determine normalized cost function...
00332      (chi^2 = 1/m * [dy^T * S_eps^{-1} * dy + dx^T * S_a^{-1} * dx]) */
00333      for (i = 0; i < m; i++)
00334          chisq_m += POW2(gsl_vector_get(dy, i) * gsl_vector_get(sig_eps_inv, i));
00335      gsl_blas_dgemv(CblasNoTrans, 1.0, s_a_inv, dx, 0.0, x_aux);
00336      gsl_blas_ddot(dx, x_aux, &chisq_a);
00337
00338      /* Free... */
00339      gsl_vector_free(x_aux);
00340      gsl_vector_free(y_aux);
00341
00342      /* Return cost function value... */
00343      return (chisq_m + chisq_a) / (double) m;
00344  }
00345
00346  /*****
00347
00348  void matrix_invert(
00349      gsl_matrix * a) {
00350
00351      size_t diag = 1, i, j, n;
00352
00353      /* Get size... */
00354      n = a->size1;
00355
00356      /* Check if matrix is diagonal... */
00357      for (i = 0; i < n && diag; i++)
00358          for (j = i + 1; j < n; j++)
00359              if (gsl_matrix_get(a, i, j) != 0) {
00360                  diag = 0;
00361                  break;
00362              }
00363
00364      /* Quick inversion of diagonal matrix... */
00365      if (diag)
00366          for (i = 0; i < n; i++)
00367              gsl_matrix_set(a, i, i, 1 / gsl_matrix_get(a, i, i));
00368
00369      /* Matrix inversion by means of Cholesky decomposition... */
00370      else {
00371          gsl_linalg_cholesky_decomp(a);
00372          gsl_linalg_cholesky_invert(a);
00373      }
00374  }
00375
00376  /*****
00377
00378  void matrix_product(
00379      gsl_matrix * a,
00380      gsl_vector * b,
00381      int transpose,
00382      gsl_matrix * c) {

```

```

00383
00384     gsl_matrix *aux;
00385
00386     size_t i, j, m, n;
00387
00388     /* Set sizes... */
00389     m = a->size1;
00390     n = a->size2;
00391
00392     /* Allocate... */
00393     aux = gsl_matrix_alloc(m, n);
00394
00395     /* Compute A^T B A... */
00396     if (transpose == 1) {
00397
00398         /* Compute B^1/2 A... */
00399         for (i = 0; i < m; i++)
00400             for (j = 0; j < n; j++)
00401                 gsl_matrix_set(aux, i, j,
00402                               gsl_vector_get(b, i) * gsl_matrix_get(a, i, j));
00403
00404         /* Compute A^T B A = (B^1/2 A)^T (B^1/2 A)... */
00405         gsl_blas_dgemm(CblasTrans, CblasNoTrans, 1.0, aux, aux, 0.0, c);
00406     }
00407
00408     /* Compute A B A^T... */
00409     else if (transpose == 2) {
00410
00411         /* Compute A B^1/2... */
00412         for (i = 0; i < m; i++)
00413             for (j = 0; j < n; j++)
00414                 gsl_matrix_set(aux, i, j,
00415                               gsl_matrix_get(a, i, j) * gsl_vector_get(b, j));
00416
00417         /* Compute A B A^T = (A B^1/2) (A B^1/2)^T... */
00418         gsl_blas_dgemm(CblasNoTrans, CblasTrans, 1.0, aux, aux, 0.0, c);
00419     }
00420
00421     /* Free... */
00422     gsl_matrix_free(aux);
00423 }
00424
00425 /*****
00426
00427 void optimal_estimation(
00428     ret_t * ret,
00429     ctl_t * ctl,
00430     obs_t * obs_meas,
00431     obs_t * obs_i,
00432     atm_t * atm_apr,
00433     atm_t * atm_i) {
00434
00435     static int ipa[N], iqa[N];
00436
00437     gsl_matrix *a, *auxnm, *corr, *cov, *gain, *k_i, *s_a_inv;
00438     gsl_vector *b, *dx, *dy, *sig_eps_inv, *sig_formod, *sig_noise,
00439             *x_a, *x_i, *x_step, *y_aux, *y_i, *y_m;
00440
00441     FILE *out;
00442
00443     char filename[LEN];
00444
00445     double chisq, chisq_old, disq = 0, lmpar = 0.001;
00446
00447     int ig, ip, it = 0, it2, iw;
00448
00449     size_t i, j, m, n;
00450
00451     /* -----
00452        Initialize...
00453        ----- */
00454
00455     /* Get sizes... */
00456     m = obs2y(ctl, obs_meas, NULL, NULL, NULL);
00457     n = atm2x(ctl, atm_apr, NULL, iqa, ipa);
00458     if (m <= 0 || n <= 0)
00459         ERRMSG("Check problem definition!");
00460
00461     /* Write info... */
00462     printf("Problem size: m= %d / n= %d "
00463           "(alloc= %.4g MB / stat= %.4g MB)\n",
00464           (int) m, (int) n,
00465           (double) (3 * m * n + 4 * n * n + 8 * m +
00466                   8 * n) * sizeof(double) / 1024. / 1024.,
00467           (double) (5 * sizeof(atm_t) + 3 * sizeof(obs_t)
00468                   + 2 * N * sizeof(int)) / 1024. / 1024.);
00469

```

```

00470  /* Allocate... */
00471  a = gsl_matrix_alloc(n, n);
00472  cov = gsl_matrix_alloc(n, n);
00473  k_i = gsl_matrix_alloc(m, n);
00474  s_a_inv = gsl_matrix_alloc(n, n);
00475
00476  b = gsl_vector_alloc(n);
00477  dx = gsl_vector_alloc(n);
00478  dy = gsl_vector_alloc(m);
00479  sig_eps_inv = gsl_vector_alloc(m);
00480  sig_formod = gsl_vector_alloc(m);
00481  sig_noise = gsl_vector_alloc(m);
00482  x_a = gsl_vector_alloc(n);
00483  x_i = gsl_vector_alloc(n);
00484  x_step = gsl_vector_alloc(n);
00485  y_aux = gsl_vector_alloc(m);
00486  y_i = gsl_vector_alloc(m);
00487  y_m = gsl_vector_alloc(m);
00488
00489  /* Set initial state... */
00490  copy_atm(ctl, atm_i, atm_apr, 0);
00491  copy_obs(ctl, obs_i, obs_meas, 0);
00492  formod(ctl, atm_i, obs_i);
00493
00494  /* Set state vectors and observation vectors... */
00495  atm2x(ctl, atm_apr, x_a, NULL, NULL);
00496  atm2x(ctl, atm_i, x_i, NULL, NULL);
00497  obs2y(ctl, obs_meas, y_m, NULL, NULL);
00498  obs2y(ctl, obs_i, y_i, NULL, NULL);
00499
00500  /* Set inverse a priori covariance S_a^-1... */
00501  set_cov_apr(ret, ctl, atm_apr, iqa, ipa, s_a_inv);
00502  write_matrix(ret->dir, "matrix_cov_apr.tab", ctl, s_a_inv,
00503              atm_i, obs_i, "x", "x", "r");
00504  matrix_invert(s_a_inv);
00505
00506  /* Get measurement errors... */
00507  set_cov_meas(ret, ctl, obs_meas, sig_noise, sig_formod, sig_eps_inv);
00508
00509  /* Create cost function file... */
00510  sprintf(filename, "%s/costs.tab", ret->dir);
00511  if (!(out = fopen(filename, "w")))
00512      ERRMSG("Cannot create cost function file!");
00513
00514  /* Write header... */
00515  fprintf(out,
00516          "# $1 = iteration number\n"
00517          "# $2 = normalized cost function\n"
00518          "# $3 = number of measurements\n"
00519          "# $4 = number of state vector elements\n\n");
00520
00521  /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00522  gsl_vector_memcpy(dx, x_i);
00523  gsl_vector_sub(dx, x_a);
00524  gsl_vector_memcpy(dy, y_m);
00525  gsl_vector_sub(dy, y_i);
00526
00527  /* Compute cost function... */
00528  chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00529
00530  /* Write info... */
00531  printf("it= %d / chi^2/m= %g\n", it, chisq);
00532
00533  /* Write to cost function file... */
00534  fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00535
00536  /* Compute initial kernel... */
00537  kernel(ctl, atm_i, obs_i, k_i);
00538
00539  /* -----
00540     Levenberg-Marquardt minimization...
00541     ----- */
00542
00543  /* Outer loop... */
00544  for (it = 1; it <= ret->conv_itmax; it++) {
00545
00546      /* Store current cost function value... */
00547      chisq_old = chisq;
00548
00549      /* Compute kernel matrix K_i... */
00550      if (it > 1 && it % ret->kernel_recomp == 0)
00551          kernel(ctl, atm_i, obs_i, k_i);
00552
00553      /* Compute K_i^T * S_eps^{-1} * K_i ... */
00554      if (it == 1 || it % ret->kernel_recomp == 0)
00555          matrix_product(k_i, sig_eps_inv, 1, cov);
00556

```



```

00557      /* Determine  $b = K_i^T * S_{eps}^{-1} * dy - S_a^{-1} * dx \dots$  */
00558      for (i = 0; i < m; i++)
00559          gsl_vector_set(y_aux, i, gsl_vector_get(dy, i)
00560                          * POW2(gsl_vector_get(sig_eps_inv, i)));
00561      gsl_blas_dgemv(CblasTrans, 1.0, k_i, y_aux, 0.0, b);
00562      gsl_blas_dgemv(CblasNoTrans, -1.0, s_a_inv, dx, 1.0, b);
00563
00564      /* Inner loop... */
00565      for (it2 = 0; it2 < 20; it2++) {
00566
00567          /* Compute  $A = (1 + lmpar) * S_a^{-1} + K_i^T * S_{eps}^{-1} * K_i \dots$  */
00568          gsl_matrix_memcpy(a, s_a_inv);
00569          gsl_matrix_scale(a, 1 + lmpar);
00570          gsl_matrix_add(a, cov);
00571
00572          /* Solve  $A * x_{step} = b$  by means of Cholesky decomposition... */
00573          gsl_linalg_cholesky_decomp(a);
00574          gsl_linalg_cholesky_solve(a, b, x_step);
00575
00576          /* Update atmospheric state... */
00577          gsl_vector_add(x_i, x_step);
00578          copy_atm(ctl, atm_i, atm_apr, 0);
00579          copy_obs(ctl, obs_i, obs_meas, 0);
00580          x2atm(ctl, x_i, atm_i);
00581
00582          /* Check atmospheric state... */
00583          for (ip = 0; ip < atm_i->np; ip++) {
00584              atm_i->p[ip] = GSL_MIN(GSL_MAX(atm_i->p[ip], 5e-7), 5e4);
00585              atm_i->t[ip] = GSL_MIN(GSL_MAX(atm_i->t[ip], 100), 400);
00586              for (ig = 0; ig < ctl->ng; ig++)
00587                  atm_i->q[ig][ip] = GSL_MIN(GSL_MAX(atm_i->q[ig][ip], 0), 1);
00588              for (iw = 0; iw < ctl->nw; iw++)
00589                  atm_i->k[iw][ip] = GSL_MAX(atm_i->k[iw][ip], 0);
00590          }
00591
00592          /* Forward calculation... */
00593          formod(ctl, atm_i, obs_i);
00594          obs2y(ctl, obs_i, y_i, NULL, NULL);
00595
00596          /* Determine  $dx = x_i - x_a$  and  $dy = y - F(x_i) \dots$  */
00597          gsl_vector_memcpy(dx, x_i);
00598          gsl_vector_sub(dx, x_a);
00599          gsl_vector_memcpy(dy, y_m);
00600          gsl_vector_sub(dy, y_i);
00601
00602          /* Compute cost function... */
00603          chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00604
00605          /* Modify Levenberg-Marquardt parameter... */
00606          if (chisq > chisq_old) {
00607              lmpar *= 10;
00608              gsl_vector_sub(x_i, x_step);
00609          } else {
00610              lmpar /= 10;
00611              break;
00612          }
00613      }
00614
00615      /* Write info... */
00616      printf("it= %d /  $\chi^2/m= %g$ \n", it, chisq);
00617
00618      /* Write to cost function file... */
00619      fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00620
00621      /* Get normalized step size in state space... */
00622      gsl_blas_ddot(x_step, b, &disq);
00623      disq /= (double) n;
00624
00625      /* Convergence test... */
00626      if ((it == 1 || it % ret->kernel_recomp == 0) && disq < ret->
conv_dmin)
00627          break;
00628      }
00629
00630      /* Close cost function file... */
00631      fclose(out);
00632
00633      /* Store results... */
00634      write_atm(ret->dir, "atm_final.tab", ctl, atm_i);
00635      write_obs(ret->dir, "obs_final.tab", ctl, obs_i);
00636      write_matrix(ret->dir, "matrix_kernel.tab", ctl, k_i,
00637                  atm_i, obs_i, "y", "x", "r");
00638
00639      /* -----
00640      Analysis of retrieval results...
00641      ----- */
00642

```

```

00643  /* Check if error analysis is requested... */
00644  if (ret->err_ana) {
00645
00646      /* Allocate... */
00647      auxnm = gsl_matrix_alloc(n, m);
00648      corr = gsl_matrix_alloc(n, n);
00649      gain = gsl_matrix_alloc(n, m);
00650
00651      /* Compute inverse retrieval covariance...
00652       $\text{cov}^{-1} = \text{S}_a^{-1} + \text{K}_i^T * \text{S}_{\text{eps}}^{-1} * \text{K}_i$  */
00653      matrix_product(k_i, sig_eps_inv, 1, cov);
00654      gsl_matrix_add(cov, s_a_inv);
00655
00656      /* Compute retrieval covariance... */
00657      matrix_invert(cov);
00658      write_matrix(ret->dir, "matrix_cov_ret.tab", ctl, cov,
00659                  atm_i, obs_i, "x", "x", "r");
00660      write_stddev("total", ret, ctl, atm_i, cov);
00661
00662      /* Compute correlation matrix... */
00663      for (i = 0; i < n; i++)
00664          for (j = 0; j < n; j++)
00665              gsl_matrix_set(corr, i, j, gsl_matrix_get(cov, i, j)
00666                             / sqrt(gsl_matrix_get(cov, i, i))
00667                             / sqrt(gsl_matrix_get(cov, j, j)));
00668      write_matrix(ret->dir, "matrix_corr.tab", ctl, corr,
00669                  atm_i, obs_i, "x", "x", "r");
00670
00671      /* Compute gain matrix...
00672       $G = \text{cov} * \text{K}^T * \text{S}_{\text{eps}}^{-1}$  */
00673      for (i = 0; i < n; i++)
00674          for (j = 0; j < m; j++)
00675              gsl_matrix_set(auxnm, i, j, gsl_matrix_get(k_i, j, i)
00676                             * POW2(gsl_vector_get(sig_eps_inv, j)));
00677      gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, cov, auxnm, 0.0, gain);
00678      write_matrix(ret->dir, "matrix_gain.tab", ctl, gain,
00679                  atm_i, obs_i, "x", "y", "c");
00680
00681      /* Compute retrieval error due to noise... */
00682      matrix_product(gain, sig_noise, 2, a);
00683      write_stddev("noise", ret, ctl, atm_i, a);
00684
00685      /* Compute retrieval error due to forward model errors... */
00686      matrix_product(gain, sig_formod, 2, a);
00687      write_stddev("formod", ret, ctl, atm_i, a);
00688
00689      /* Compute averaging kernel matrix
00690       $A = G * K \dots$  */
00691      gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, gain, k_i, 0.0, a);
00692      write_matrix(ret->dir, "matrix_avk.tab", ctl, a,
00693                  atm_i, obs_i, "x", "x", "r");
00694
00695      /* Analyze averaging kernel matrix... */
00696      analyze_avk(ret, ctl, atm_i, iqa, ipa, a);
00697
00698      /* Free... */
00699      gsl_matrix_free(auxnm);
00700      gsl_matrix_free(corr);
00701      gsl_matrix_free(gain);
00702  }
00703
00704  /* -----
00705      Finalize...
00706      ----- */
00707
00708  gsl_matrix_free(a);
00709  gsl_matrix_free(cov);
00710  gsl_matrix_free(k_i);
00711  gsl_matrix_free(s_a_inv);
00712
00713  gsl_vector_free(b);
00714  gsl_vector_free(dx);
00715  gsl_vector_free(dy);
00716  gsl_vector_free(sig_eps_inv);
00717  gsl_vector_free(sig_formod);
00718  gsl_vector_free(sig_noise);
00719  gsl_vector_free(x_a);
00720  gsl_vector_free(x_i);
00721  gsl_vector_free(x_step);
00722  gsl_vector_free(y_aux);
00723  gsl_vector_free(y_i);
00724  gsl_vector_free(y_m);
00725  }
00726
00727  /*****
00728
00729  void read_ret (

```

```

00730     int argc,
00731     char *argv[],
00732     ctl_t *ctl,
00733     ret_t *ret) {
00734
00735     int id, ig, iw;
00736
00737     /* Iteration control... */
00738     ret->kernel_recomp =
00739         (int) scan_ctl(argc, argv, "KERNEL_RECOMP", -1, "3", NULL);
00740     ret->conv_itmax = (int) scan_ctl(argc, argv, "CONV_ITMAX", -1, "30", NULL);
00741     ret->conv_dmin = scan_ctl(argc, argv, "CONV_DMIN", -1, "0.1", NULL);
00742
00743     /* Error analysis... */
00744     ret->err_ana = (int) scan_ctl(argc, argv, "ERR_ANA", -1, "1", NULL);
00745
00746     for (id = 0; id < ctl->nd; id++)
00747         ret->err_formod[id] = scan_ctl(argc, argv, "ERR_FORMOD", id, "0", NULL);
00748
00749     for (id = 0; id < ctl->nd; id++)
00750         ret->err_noise[id] = scan_ctl(argc, argv, "ERR_NOISE", id, "0", NULL);
00751
00752     ret->err_press = scan_ctl(argc, argv, "ERR_PRESS", -1, "0", NULL);
00753     ret->err_press_cz = scan_ctl(argc, argv, "ERR_PRESS_CZ", -1, "-999", NULL);
00754     ret->err_press_ch = scan_ctl(argc, argv, "ERR_PRESS_CH", -1, "-999", NULL);
00755
00756     ret->err_temp = scan_ctl(argc, argv, "ERR_TEMP", -1, "0", NULL);
00757     ret->err_temp_cz = scan_ctl(argc, argv, "ERR_TEMP_CZ", -1, "-999", NULL);
00758     ret->err_temp_ch = scan_ctl(argc, argv, "ERR_TEMP_CH", -1, "-999", NULL);
00759
00760     for (ig = 0; ig < ctl->ng; ig++) {
00761         ret->err_q[ig] = scan_ctl(argc, argv, "ERR_Q", ig, "0", NULL);
00762         ret->err_q_cz[ig] = scan_ctl(argc, argv, "ERR_Q_CZ", ig, "-999", NULL);
00763         ret->err_q_ch[ig] = scan_ctl(argc, argv, "ERR_Q_CH", ig, "-999", NULL);
00764     }
00765
00766     for (iw = 0; iw < ctl->nw; iw++) {
00767         ret->err_k[iw] = scan_ctl(argc, argv, "ERR_K", iw, "0", NULL);
00768         ret->err_k_cz[iw] = scan_ctl(argc, argv, "ERR_K_CZ", iw, "-999", NULL);
00769         ret->err_k_ch[iw] = scan_ctl(argc, argv, "ERR_K_CH", iw, "-999", NULL);
00770     }
00771 }
00772
00773 /*****
00774
00775 void set_cov_apr(
00776     ret_t *ret,
00777     ctl_t *ctl,
00778     atm_t *atm,
00779     int *iqa,
00780     int *ipa,
00781     gsl_matrix *s_a) {
00782
00783     gsl_vector *x_a;
00784
00785     double ch, cz, rho, x0[3], x1[3];
00786
00787     int ig, iw;
00788
00789     size_t i, j, n;
00790
00791     /* Get sizes... */
00792     n = s_a->size1;
00793
00794     /* Allocate... */
00795     x_a = gsl_vector_alloc(n);
00796
00797     /* Get sigma vector... */
00798     atm2x(ctl, atm, x_a, NULL, NULL);
00799     for (i = 0; i < n; i++) {
00800         if (iqa[i] == IDXP)
00801             gsl_vector_set(x_a, i, ret->err_press / 100 * gsl_vector_get(x_a, i));
00802         if (iqa[i] == IDXT)
00803             gsl_vector_set(x_a, i, ret->err_temp);
00804         for (ig = 0; ig < ctl->ng; ig++)
00805             if (iqa[i] == IDXQ(ig))
00806                 gsl_vector_set(x_a, i, ret->err_q[ig] / 100 * gsl_vector_get(x_a, i));
00807         for (iw = 0; iw < ctl->nw; iw++)
00808             if (iqa[i] == IDXK(iw))
00809                 gsl_vector_set(x_a, i, ret->err_k[iw]);
00810     }
00811
00812     /* Check standard deviations... */
00813     for (i = 0; i < n; i++)
00814         if (POW2(gsl_vector_get(x_a, i)) <= 0)
00815             ERRMSG("Check a priori data (zero standard deviation)!");
00816

```

```

00817  /* Initialize diagonal covariance... */
00818  gsl_matrix_set_zero(s_a);
00819  for (i = 0; i < n; i++)
00820      gsl_matrix_set(s_a, i, i, POW2(gsl_vector_get(x_a, i)));
00821
00822  /* Loop over matrix elements... */
00823  for (i = 0; i < n; i++)
00824      for (j = 0; j < n; j++)
00825          if (i != j && iqa[i] == iqa[j]) {
00826
00827              /* Initialize... */
00828              cz = ch = 0;
00829
00830              /* Set correlation lengths for pressure... */
00831              if (iqa[i] == IDXP) {
00832                  cz = ret->err_press_cz;
00833                  ch = ret->err_press_ch;
00834              }
00835
00836              /* Set correlation lengths for temperature... */
00837              if (iqa[i] == IDXT) {
00838                  cz = ret->err_temp_cz;
00839                  ch = ret->err_temp_ch;
00840              }
00841
00842              /* Set correlation lengths for volume mixing ratios... */
00843              for (ig = 0; ig < ctl->ng; ig++)
00844                  if (iqa[i] == IDXQ(ig)) {
00845                      cz = ret->err_q_cz[ig];
00846                      ch = ret->err_q_ch[ig];
00847                  }
00848
00849              /* Set correlation lengths for extinction... */
00850              for (iw = 0; iw < ctl->nw; iw++)
00851                  if (iqa[i] == IDXK(iw)) {
00852                      cz = ret->err_k_cz[iw];
00853                      ch = ret->err_k_ch[iw];
00854                  }
00855
00856              /* Compute correlations... */
00857              if (cz > 0 && ch > 0) {
00858
00859                  /* Get Cartesian coordinates... */
00860                  geo2cart(0, atm->lon[ipa[i]], atm->lat[ipa[i]], x0);
00861                  geo2cart(0, atm->lon[ipa[j]], atm->lat[ipa[j]], x1);
00862
00863                  /* Compute correlations... */
00864                  rho =
00865                      exp(-DIST(x0, x1) / ch -
00866                         fabs(atm->z[ipa[i]] - atm->z[ipa[j]]) / cz);
00867
00868                  /* Set covariance... */
00869                  gsl_matrix_set(s_a, i, j, gsl_vector_get(x_a, i)
00870                                * gsl_vector_get(x_a, j) * rho);
00871              }
00872          }
00873
00874  /* Free... */
00875  gsl_vector_free(x_a);
00876 }
00877
00878 /*****
00879
00880 void set_cov_meas(
00881     ret_t * ret,
00882     ctl_t * ctl,
00883     obs_t * obs,
00884     gsl_vector * sig_noise,
00885     gsl_vector * sig_formod,
00886     gsl_vector * sig_eps_inv) {
00887
00888     static obs_t obs_err;
00889
00890     int id, ir;
00891
00892     size_t i, m;
00893
00894     /* Get size... */
00895     m = sig_eps_inv->size;
00896
00897     /* Noise error (always considered in retrieval fit)... */
00898     copy_obs(ctl, &obs_err, obs, 1);
00899     for (ir = 0; ir < obs_err.nr; ir++)
00900         for (id = 0; id < ctl->nd; id++)
00901             obs_err.rad[id][ir]
00902                 = (gsl_finite(obs->rad[id][ir]) ? ret->err_noise[id] : GSL_NAN);
00903     obs2y(ctl, &obs_err, sig_noise, NULL, NULL);

```

```

00904
00905  /* Forward model error (always considered in retrieval fit)... */
00906  copy_obs(ctl, &obs_err, obs, 1);
00907  for (ir = 0; ir < obs_err.nr; ir++)
00908      for (id = 0; id < ctl->nd; id++)
00909          obs_err.rad[id][ir]
00910              = fabs(ret->err_formod[id] / 100 * obs->rad[id][ir]);
00911  obs2y(ctl, &obs_err, sig_formod, NULL, NULL);
00912
00913  /* Total error... */
00914  for (i = 0; i < m; i++)
00915      gsl_vector_set(sig_eps_inv, i, 1 / sqrt(POW2(gsl_vector_get(sig_noise, i))
00916                                              +
00917                                              POW2(gsl_vector_get
00918                                                  (sig_formod, i))));
00919
00920  /* Check standard deviations... */
00921  for (i = 0; i < m; i++)
00922      if (gsl_vector_get(sig_eps_inv, i) <= 0)
00923          ERRMSG("Check measurement errors (zero standard deviation)!");
00924 }
00925
00926 /*****
00927
00928 void write_stddev(
00929     const char *quantity,
00930     ret_t *ret,
00931     ctl_t *ctl,
00932     atm_t *atm,
00933     gsl_matrix *s) {
00934
00935     static atm_t atm_aux;
00936
00937     gsl_vector *x_aux;
00938
00939     char filename[LEN];
00940
00941     size_t i, n;
00942
00943     /* Get sizes... */
00944     n = s->size1;
00945
00946     /* Allocate... */
00947     x_aux = gsl_vector_alloc(n);
00948
00949     /* Compute standard deviation... */
00950     for (i = 0; i < n; i++)
00951         gsl_vector_set(x_aux, i, sqrt(gsl_matrix_get(s, i, i)));
00952
00953     /* Write to disk... */
00954     copy_atm(ctl, &atm_aux, atm, 1);
00955     x2atm(ctl, x_aux, &atm_aux);
00956     sprintf(filename, "atm_err_%s.tab", quantity);
00957     write_atm(ret->dir, filename, ctl, &atm_aux);
00958
00959     /* Free... */
00960     gsl_vector_free(x_aux);
00961 }

```

## 5.29 time2jsec.c File Reference

Convert date to Julian seconds.

### Functions

- int [main](#) (int argc, char \*argv[])

#### 5.29.1 Detailed Description

Convert date to Julian seconds.

Definition in file [time2jsec.c](#).

## 5.29.2 Function Documentation

## 5.29.2.1 int main ( int argc, char \* argv[] )

Definition at line 27 of file [time2jsec.c](#).

```

00029         {
00030
00031     double jsec, remain;
00032
00033     int day, hour, min, mon, sec, year;
00034
00035     /* Check arguments... */
00036     if (argc < 8)
00037         ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039     /* Read arguments... */
00040     year = atoi(argv[1]);
00041     mon = atoi(argv[2]);
00042     day = atoi(argv[3]);
00043     hour = atoi(argv[4]);
00044     min = atoi(argv[5]);
00045     sec = atoi(argv[6]);
00046     remain = atof(argv[7]);
00047
00048     /* Convert... */
00049     time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050     printf("%.2f\n", jsec);
00051
00052     return EXIT_SUCCESS;
00053 }

```

Here is the call graph for this function:



## 5.30 time2jsec.c

```

00001 /*
00002     This file is part of JURASSIC.
00003
00004     JURASSIC is free software: you can redistribute it and/or modify
00005     it under the terms of the GNU General Public License as published by
00006     the Free Software Foundation, either version 3 of the License, or
00007     (at your option) any later version.
00008
00009     JURASSIC is distributed in the hope that it will be useful,
00010     but WITHOUT ANY WARRANTY; without even the implied warranty of
00011     MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
00012     GNU General Public License for more details.
00013
00014     You should have received a copy of the GNU General Public License
00015     along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017     Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028     int argc,
00029     char *argv[]) {

```

```
00030
00031     double jsec, remain;
00032
00033     int day, hour, min, mon, sec, year;
00034
00035     /* Check arguments... */
00036     if (argc < 8)
00037         ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039     /* Read arguments... */
00040     year = atoi(argv[1]);
00041     mon = atoi(argv[2]);
00042     day = atoi(argv[3]);
00043     hour = atoi(argv[4]);
00044     min = atoi(argv[5]);
00045     sec = atoi(argv[6]);
00046     remain = atof(argv[7]);
00047
00048     /* Convert... */
00049     time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050     printf("%.2f\n", jsec);
00051
00052     return EXIT_SUCCESS;
00053 }
```

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